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Interim Development Report for the B61-6,8 Bombs (U)

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Sandia National Laboratories, Albuquerque
Los Alamos National Laboratory

Prepared by
Sandia National Laboratories
Albuquerque, New Mexico 87185 and Livermore, California 94550
for the United States Department of Energy
under Contract DE-AC04-76DP00789

Classified by D. N. Bray, Supervisor, B61-6,7,8/W61 Division 5111, March 3, 1989.

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Interim Development Report for the B61-6,8 Bombs (U)

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Abstract (U)

This report describes the B61-6,8 bombs in development as a part of the Stockpile Improvement Program. The bomb design, its ancillary and support equipment, and the planned test and evaluation program are presented.

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Figures (continued)

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Foreward

The B61-6,8 bombs will result from a factory retrofit of the B61-0,2,and 5 bombs. This retrofit is being conducted as part of the B61 Stockpile Improvement Program (SIP). The goal of the B61 SIP is to upgrade B61s in stockpile by incorporating modern design features of safety, use control, and improved operational flexibility. References 1–9 trace the stockpile reviews identifying the shortcomings of the stockpile and the recommendations for a selective retirement/retrofit program. Each of these references is reproduced in Appendix A of the B61-7 Weapon Development Report[10] and summarized in the foreward of that document. The mechanical and electrical design of the B61-6,8 is very similar to the B61-7, an ongoing retrofit of the B61-1 scheduled to be completed in September 1990.

The SIP does not follow the normal nuclear weapon path of authorizations and approvals. No Ø1 through Ø3 activities occur. The first authorization occurred with the release of the Nuclear Weapons Production and Planning Directive (P&PD) issued by the Director of Military Applications in March 1987 scheduling the production of the B61-6,8. Phase 4 authorization was granted by DOE/AL November 1987. Since stockpile assets are required for the B61-6,8 production, a Product Change Proposal was coordinated through Field Command, DNA defining the effect of the retrofit. The PCP for the B61-6 was approved in April 1988.

At this time, the DOE/DoD coordinated draft Military Characteristics for the B61-6,8 await NWCSC approval. The Interim Design Review and Acceptance Group (DRAAG) is tentatively scheduled for May 1989.

Summary

The B61-6,8 is a factory retrofit of the B61-0,2,5, utilizing an IHE nuclear primary and enhanced electrical safety components. Use control, command disable, and improved operational flexibility features are also included. The B61-6,8 was designed to be compatible with all aircraft now approved for B61 carriage. Compatibility will only be demonstrated for those Navy aircraft listed in the MCs: A-4, A-6, A-7, F/A-18, and A-12 (when available). No known problems exist.

The B61-6,8 will be fielded to be compatible with aircraft employing AMACs without Intent Unique Signal (IUQS) generators through the employment of the MC3025 Signal Selector. The MC3025 will be removed from all bombs on or before 1 January, 2000. Only aircraft with IUQS-capable AMACs will be compatible after this time.

Significant design features of the B61-6,8 are as follows:

Physical:

Length	3597 mm (141.6 in.)
Diameter	338 mm (13.3 in.)
Weight	350 kg (770 lb)

Yields:

[redacted]

DOD/DOE b(3)

Delivery Options:
- Freefall Airburst (FFA)
- Freefall Groundburst (FFG)
- Retarded Airburst (REA)
- Retarded Groundburst, Laydown (REG)

Aircraft Delivery Constraints:
- Certified to maximum aircraft capabilities

[redacted]

DOD/DOE b(3)

Safety:
- Use of IHE for primary explosive
- Primary is inherently one-point safe
- Enhanced electrical safety to meet modern nuclear safety standards

Use Control:

[redacted]

DOD b(3)

Limited Life Components:

[redacted]

DOD/DOE b(3)

Intrinsic Radiation:

[redacted]

DOD b(3)

Interim Development Report for the B61-6,8 Bombs

1. B61-6,8 Overview

Design Objective

The B61 Stockpile Improvement Program objective is to upgrade all B61 bombs to incorporate modern design features of safety, use control, and improved operational flexibility.

Design Characteristics

The B61-6,8 will provide enhanced nuclear detonation safety and plutonium scatter safety in abnormal (accident) environments by the use of: (1) exclusion region isolation of safety-critical electrical circuits with colocated weak-link and stronglink devices, (2) prearm and post-release unique signal control of strong links, and (3) insensitive high explosive (IHE). Use control is provided by Category D Permissive Action Link (PAL) and nonviolent command disable (CD) [redacted] assuming proper electrical and environmental inputs. Tests and analyses have been performed to evaluate the response of the bomb to the Stockpile-to-Target Sequence (STS) environments.

The physical characteristics of the B61-6,8 are:

Weight	350 kg (770 lb)
Diameter	338 mm (13.3 in.)
Length	3597 mm (141.6 in.)
CG location	1530 mm (60.25 in.) from nose

No field testing or maintenance is required other than at the time of limited life component exchange. Field mainte- [redacted]

DoD/DOE b(3)

Exceptions/Limitations

None; the B61-6,8 meets all MCs. The MC reliability [redacted]

2. Bomb Description

General

The B61-6,8 is a major modification to the B61-0,2,5 bombs in stockpile. Return of B61-0,2,5s to the DOE production facility is required for the conversion to be performed. To reduce production costs, maximum reuse is made of returned bomb components. Table 1 indicates the major parts from the returned, or "parent," weapon, and the new production parts that make up a B61-6,8 bomb. "Carryover" design parts from the B61-7 program currently in production were used when possible to save development and production costs.

DoD/DoE b(3)

Nuclear System

The nuclear system for the B61-6,8 uses the "parent"

DoD/DoE b(3)

Primary

Boost System

Table 1. Source of B61-6,8 Major Components/Assemblies

Secondary

Mechanical/Structural Design

The B61-6,8 consists of four major subassemblies (Figure 1): Radar, Center Bomb, Preflight, and Tail.

	B61-6	B61-8
Nose	MC1828	MC2807
Center Bomb	MC4110	MC4111
Preflight	MC4118	
Tail	MC4119	

MC1828 (B61-6)/MC2807 (B61-8) Bomb Radar Nose

The MC1828/MC2807 Bomb Radar Nose[11] (Figure 2) extends from Station 0 to Station 26.75 (679 mm). The attachment to the center case section is made with 36 screws, like all of the major subassembly matings on the B61. A dual channel radar and dual channel impact fuzes are located in the nose. Honeycomb material is incorporated behind the radar and impact fuze circuitry[12] to provide energy absorption during laydown.

b1

MC4110 (B61-6)/MC4111 (B61-8) Center Bomb Subassembly

The Center Bomb Subassembly consists of the nuclear system; the arming, fuzing, and firing system; and the center case section.

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MC4118 Preflight Bomb Subassembly

The MC4118 consists of the MC4136 Preflight Controller and the MC1951 Rocket Motor.[13] The preflight case section has a variable cross section with a maximum thickness of 0.75-in. (19.05 mm) 7075-T73511 aluminum cylinder and joins the center and tail case sections. The aft suspension lug bolts to the top of the preflight case section while the forward lug is secured to the center case section. Preflight case sections will be reused for the Mod 6 and 8 bomb after machining to enlarge the preflight controller access door opening.

The reused MC1951 Rocket Motor is bolted to the preflight case; its function is to spin the weapon to provide aerodynamic stabilization during freefall deliveries. Since the MC1951 is no longer in production, rebuild of NMFT and SFT units will use the MC3003 (Figure 4). Functionally and mechanically, the MC3003 is identical to the MC1951 except the ignitor in the MC3003 is a one-ampere no-fire, one-ohm device, whereas the MC1951 contains a 100 milliampere no-fire, 4.5 ohm ignitor. The electrical system is designed to fire either device.

The MC4136 Preflight Controller is also secured to the preflight case. Access to the preflight control panel is through a door in the case; this door is provided with dust and EMR seals. Several cables terminate in or pass through the preflight section interconnecting the ICU and preflight controller with components in the preflight and tail sections.

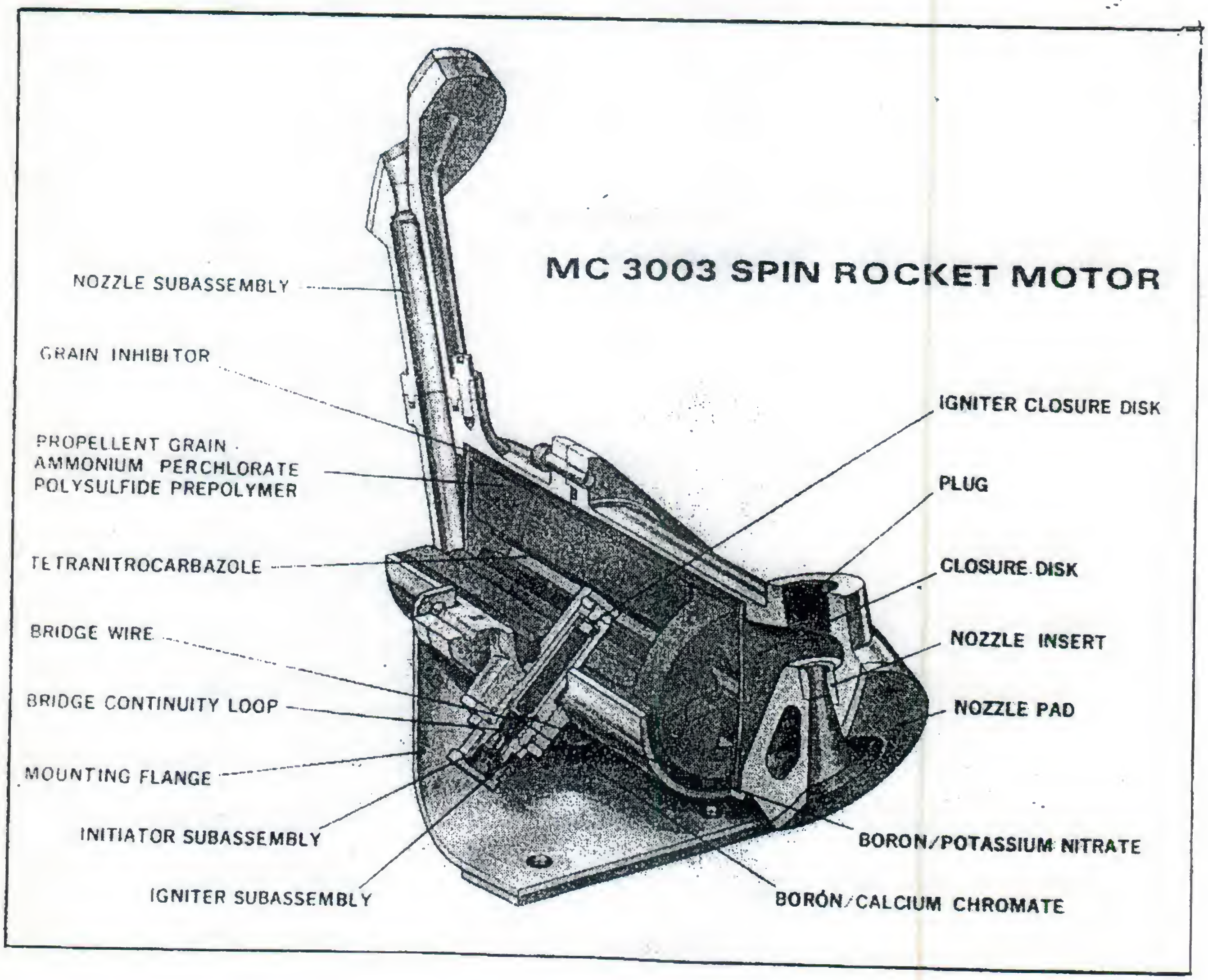

Figure 4 MC3003 Rocket Motor

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MC4119 Tail Bomb Subassembly

This subassembly includes the bomb retardation system, the MC3624 Filter Pack[14], and the MC2213 Actuator and Pulse Battery Assembly. These components are mounted within a light aluminum case to which four fins are bolted. The retardation system, which includes the MC1887A Parachute[15] and its deployment hardware, the case section, and the fins are reused from the parent bomb. The MC1887A Parachute consists of a 17-ft-diameter ribbon-type parachute packed around a set of telescoping aluminum tubes, a suspension line load ring, a deployment plate, and a set of deployment tube brakes. The parachute is deployed by firing the MC1835 Gas Generator[16] (Figure 5) into the volume enclosed by the telescoping tubes. Line stretch is obtained in approximately 0.165 seconds. For rebuild of NMFT and SFT units, the B61-6,8 will use the MC3002 Gas Generator. The differnce between the MC3002 and MC1835 is the energy requirements of the ignitor. Like the MC3003 spin rocket motor, the MC3002 employs a one-ohm, one ampere no-fire ignitor rather than the 4.5 ohm, ~580 milliampere all-fire device used in the MC1835.

The filter pack and the actuator and pulse battery assembly are bolted to the top-inside of the tail case. The filter pack's umbilical connector and the actuator and pulse battery assembly's pullout rod extend through holes in the tail case for aircraft interface connections.

B61-6,8 Mass Properties

At this time, estimates for the B61-6,8 weight, CG, and moments of inertia are based on comparisons with previous B61 mods. The components causing the largest deviations from the B61-7 will be the Acorn assembly, MC4137 TSSG, and the JTA (ballast for WR). When the fidelity of the test unit warrants, we will adjust these estimates as necessary during the development program. Final verification of mass properties will be obtained on the first few B61-6 bombs at the DOE production plant. The table below presents the best available data with comparisons to the B61 stockpile.

Table 2. B61 Mass Properties

	B61-0,1,2,5	B61-3,4	B61-6	B61-8
CG, in	60.265±.25	61.2±.5	60.26	60.16
Wt, lb	716±10	751±15	768	770

DOE 6(3)

*Moments of inertia are in lbm-in² units.

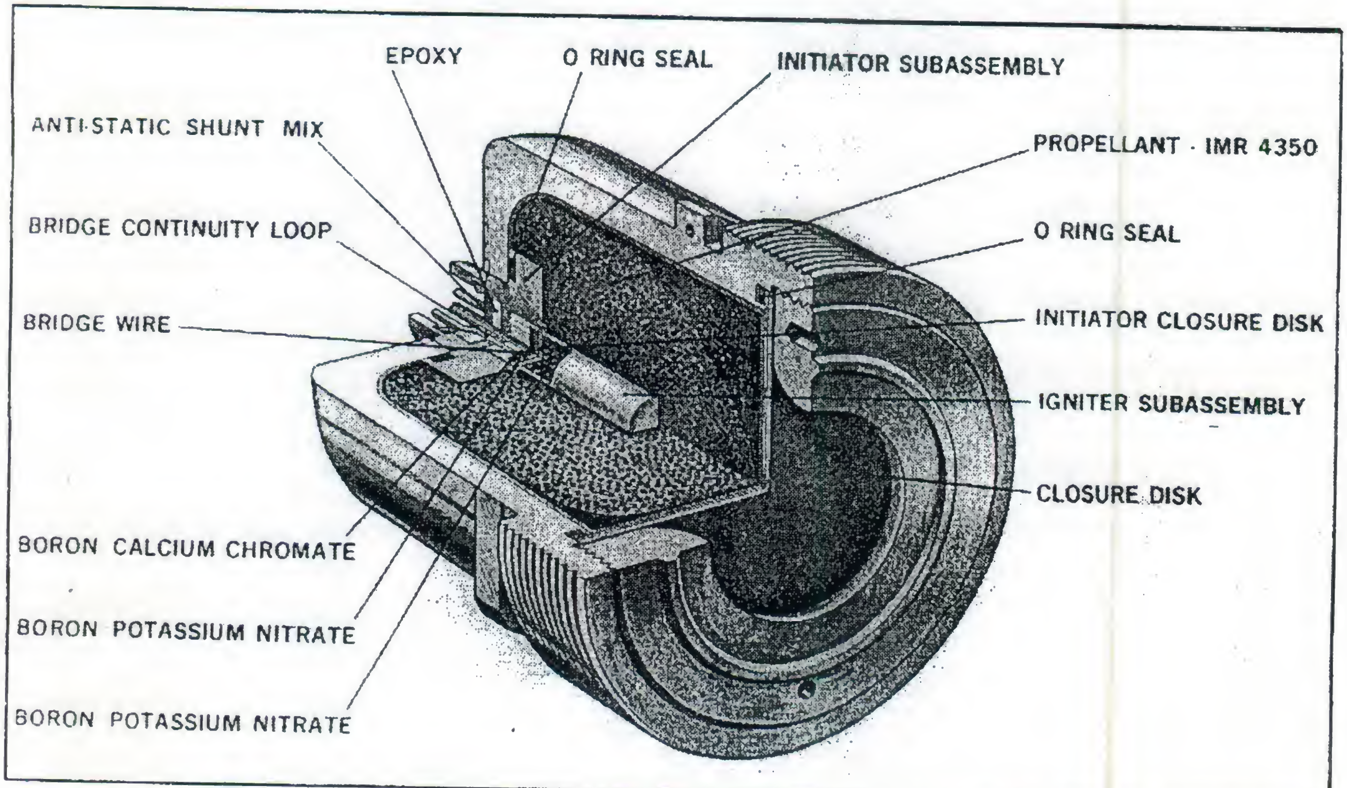


Figure 5. MC1835 Gas Generator

Electrical System

The B61-6,8 Electrical System provides all arming, fuzing, and firing signals required to initiate the nuclear system following proper prearming and delivery by strike aircraft. In addition, the MCs require that the bomb design provide stringent nuclear safety during all phases of the STS prior to bomb prearming (Chapter 4). [redacted] Use control (Chapter 6) is provided by Category D PAL and Command Disable (CD) systems. Typical aircraft/bomb operational sequences are described in Chapter 3.

Bomb electrical components that are required to survive and function following laydown delivery are contained within the center bomb subassembly. These include the MC2918 Firing Set, MC3554 Neutron Generator (2 each), MC4138 Programmer, MC3656 Main Battery (2 each), and the MC4139 Junction Box. The MC4175 (2 each) or MC4137 (one) Trajectory Sensing Signal Generators are also located in the center bomb subassembly. Electrical signals into the center bomb subassembly pass through a single MC3612 Lightning Arrestor Connector (LAC) mounted on the cover plate.

The MC4140 Interface Control Unit mounts on the preflight subassembly side of the cover plate. The MC4136 Preflight Controller mounts directly to the preflight case. Similar mounting is used to secure the MC3624 Filter Pack and the MC2213 Actuator and Pulse Battery Assembly to the tail section.

MC2918 Firing Set

[redacted]

The MC2918, which contains the major bomb safing elements, is divided into three regions that are separated by high-temperature-resistant, electrically insulating barriers.

The second region contains the transverter power amplifier circuits and the MC2935 TSLSs. All signals entering the second region pass through the MC2969 ISLS.

The third region contains the MC2918's high-voltage transformer and X-unit. Parallel 5-M thick-film resistors are provided to bleed the X-unit charge within about 5 seconds if arming power is removed. All signals entering the third region pass through the contacts of the MC2935 TSLSs. The neutron generator trigger signals are transformer-coupled through the exclusion region barrier.

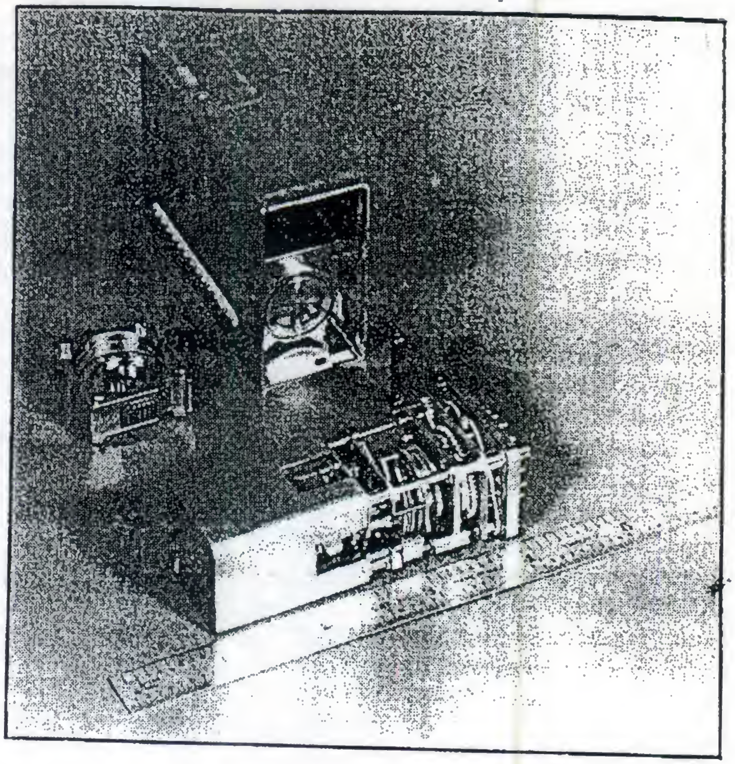
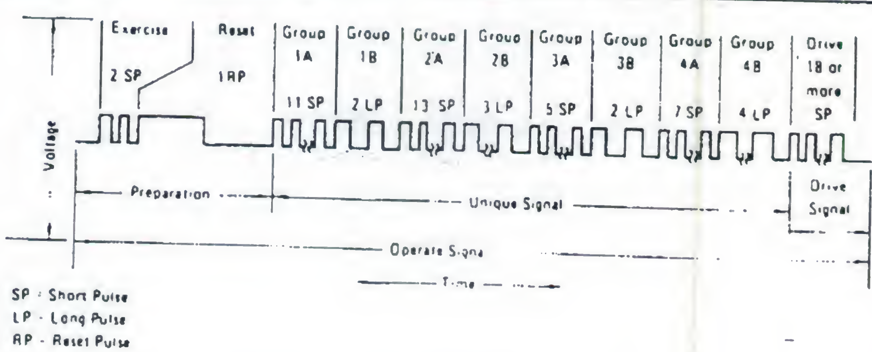


Figure 7. MC2969 Intent Stronglink Switch

MC2969 Intent Stronglink Switch

The MC2969 Intent Stronglink Switch,[19] which is currently being produced for the B61-3,4, B61-7, W78, W80, and B83, is used in the B61-6,8. The switch is part of the intent safety subsystem (Chapter 4). Functionally, the MC2969 isolates all firing set exclusion Region 2 circuits from exclusion Region 1 circuits until it receives the proper intent unique signal (IUQS) from the AMAC system. The switch, shown in Figure 7, consists of two main parts: a contact assembly of 14 ceramic insulated output switches, and an electromechanical decoder/driver that decodes the IUQS and drives the output switch assembly to closure given the proper signal (Figure 8). The drive mechanism is designed to operate the switch assembly to the closed (prearm) position after receipt of the correct IUQS pattern of short and long pulses. An incorrect IUQS pattern will lock the MC2969 switch in the open position until receipt of a safe or reset input signal. A dc safe signal or a reset pulse (greater than 1350 ms) will reset the decoder/driver and place the switch assembly in the SAFE (open) position.



UNIQUE PATTERN PORTION OF PULSE TRAIN

PULSE	DURATION (SECONDS)			
	ON		OFF	
	MIN	MAX	MIN	MAX
SHORT	0 062	0 130	0 085 + 0 4 x (ON PULSE)	NONE REQUIRED MUST BE CONSISTENT WITH MAXIMUM OPERATE TIME OF [illegible] SECONDS
LONG	0 365	0 470	ON PULSE 0 02	
RESET	1 66	2 0	ON PULSE 0 04	

Figure 8. Intent Unique Signal (IUQS)

MC2935 Trajectory Stronglink Switches

The MC2935 Trajectory Stronglink Switch,[20] which is currently being produced for the B61-3,4, B61-7, W80, and the B83 is used in the B61-6,8. This switch is part of the second nuclear safety subsystem, the trajectory safety subsystem (Chapter 4). The MC2935 isolates all firing set exclusion Region 3 circuits from exclusion Region 2 circuits until receipt of the required trajectory unique signal (TUQS). One MC2935 is used in each channel of the firing set. The switch, shown in Figure 9, consists of two main parts: a decoder/driver mechanism, and a functional contact assembly. The decoder/driver is a dual-solenoid mechanism requiring two electrical input signals to operate. The switch is designed to close the functional contacts when provided the proper TUQS shown in Figure 10.

The MC2935 is a single try device; that is, should it receive an incorrect TUQS, it will mechanically lock. Having been locked by an incorrect TUQS, it will not respond to further electrical input signals until it is manually unlocked and simultaneously reset by proper electrical reset input signals.

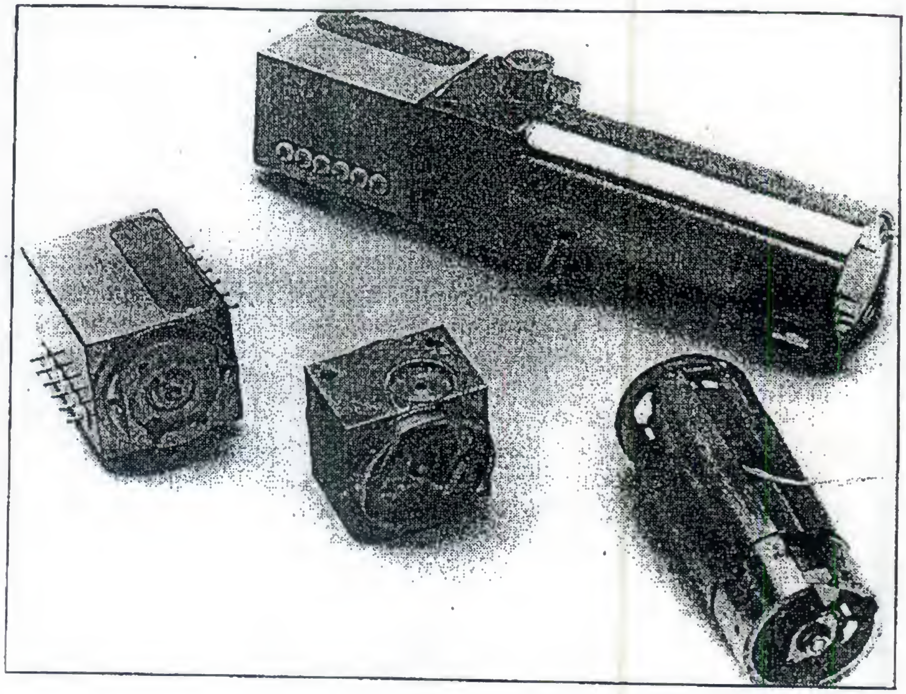


Figure 9. MC2935 Trajectory Stronglink Switch

Figure 10. Trajectory Unique Signal (TUQS)

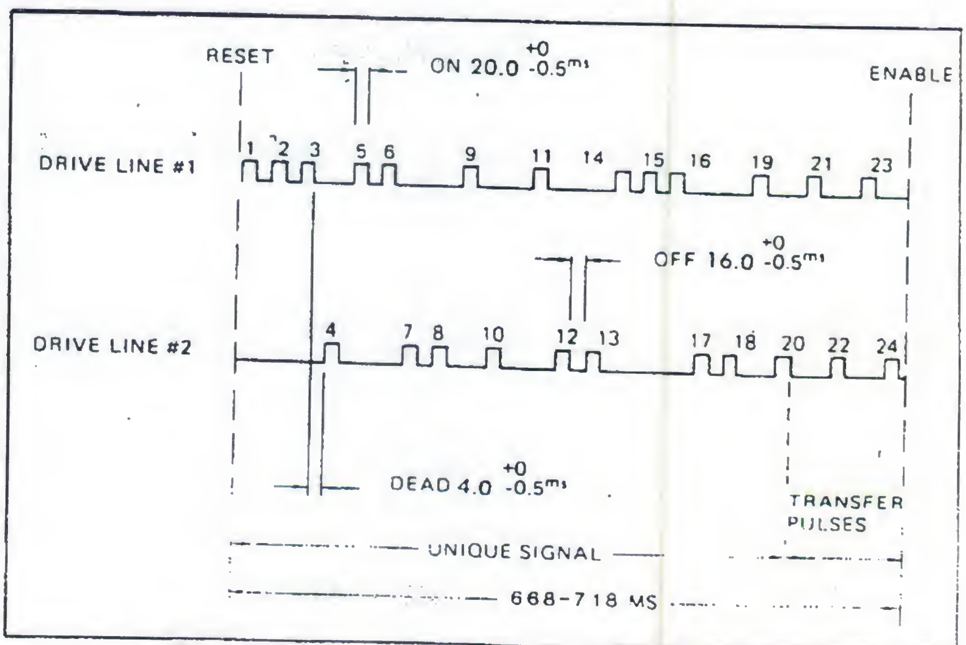


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Figure 11. MC3554 Neutron Generator

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Figure 12. MC3554 Neutron Generator, visual display and functional assemblies.

MC4141 Electrical Component Assembly (ECA)

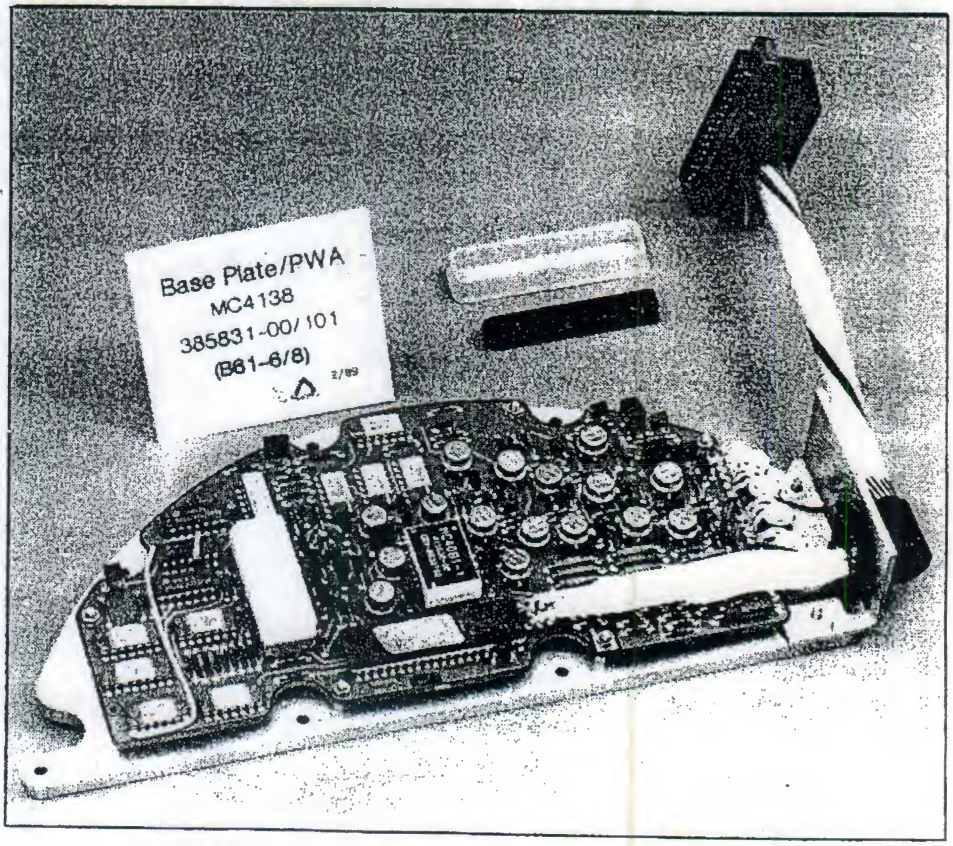
The MC4141 ECA is the third deck of components inside the center bomb subassembly (Figure 12). The ECA houses the MC4138 Programmer, MC4175 or MC4137 Trajectory Sensing Signal Generator, MC4139 Junction Box, and the MC3656 Main Batteries.

MC4138 Programmer

The MC4138 Programmer includes two independent and identical channels (Figures 13, 14). Two identical circuit boards are encapsulated in polyurethane foam in an aluminum housing unaltered from that of the B61-7 programmer. [redacted] Other functions include initiation of the main batteries, providing power and height of burst information to the radar, and receiving radar fire and crystal (impact) fire signals and transmitting them to the firing set if appropriate. To determine delivery mode and mission options, the programmer communi-

DOE DOD b(3)

Figure 13. Printed wiring assembly of a single channel of the MC4138 Programmer.



cates and receives data from the MC4140 Interface Control Unit (ICU).

Except for differences in the machined holes in the housing for heat-sink components and edentification markings, the MC3637 Programmer for the B61-7 (Figure 14) is visually identical to the MC4138 Programmer used on the B61-6,8.

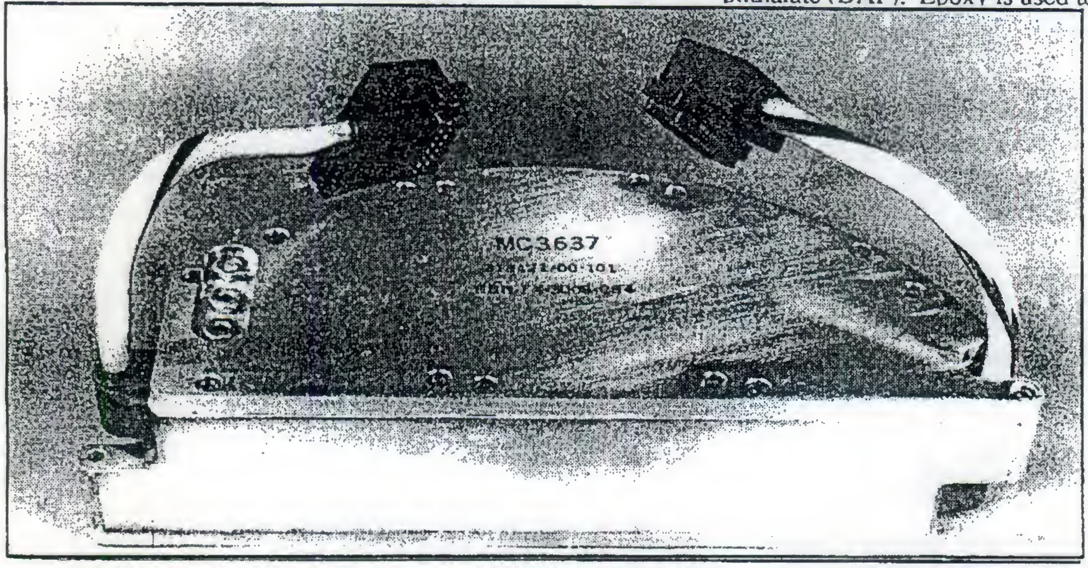


Figure 14. MC3637 Programmer

MC4175/MC4137 Trajectory Sensing Signal Generator (TSSG)

Two versions of TSSGs will be used in the B61-6,8. The MC4175 is identical to the MC3640[22] used in the B61-7 except for the pigtail connector which attaches to the MC4139 Junction Box. The new MC4137 TSSG will be available to support the B61-6 production in July 1991. The MC4175/MC4137 TSSG is part of the second nuclear safety subsystem, the trajectory safety subsystem (Chapter 4). The MC4137 differs from the MC4175 in design, construction, and nuclear detonation safety design philosophy.

MC4175 TSSG

The initial B61-6 production will use two MC4175 TSSGs. Each MC4175 contains three fluid-damped, nonlatching inertial sensing switches (rolamites) and circuitry to output the trajectory unique signal (TUQS). When powered through the rolamite switches, the trajectory unique signal generator circuitry produces the pulse train outputs necessary to operate and close the MC2935 Trajectory Stronglink Switches in the firing set.

The rolamite switches used in the MC4175 are the MC3671 (2 each) and MC3672. Both the MC3671 (Figure 15) and MC3672 use cases and end caps molded from diallyl phthalate (DAP). Epoxy is used to bond the end caps to the

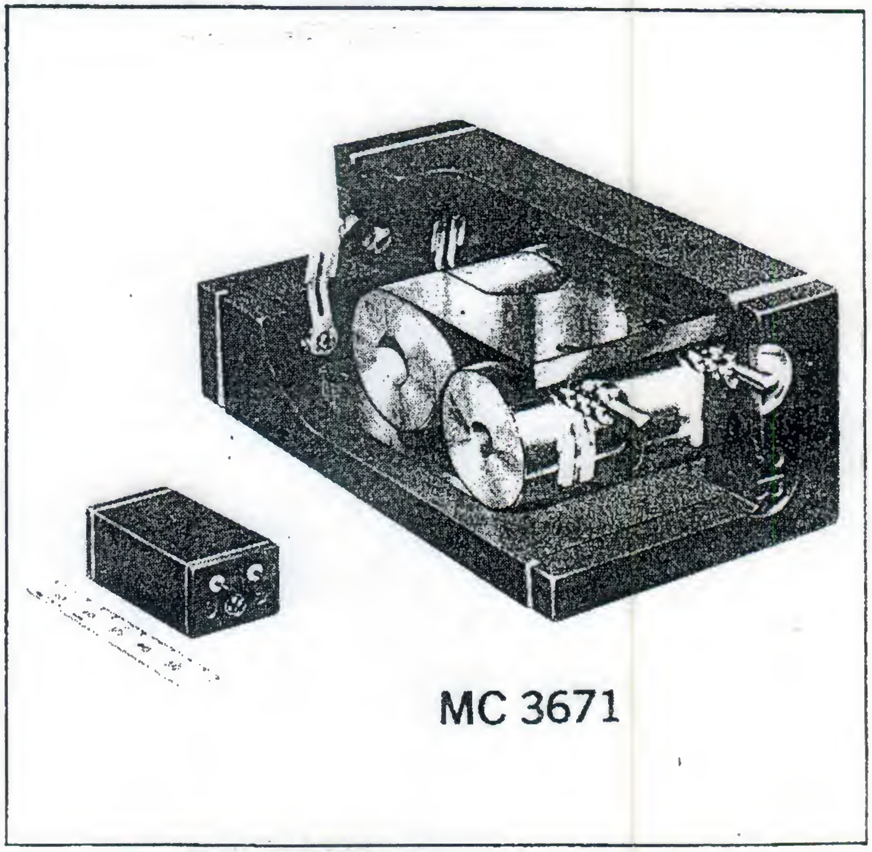


Figure 15. MC3671 Rolamite Switch

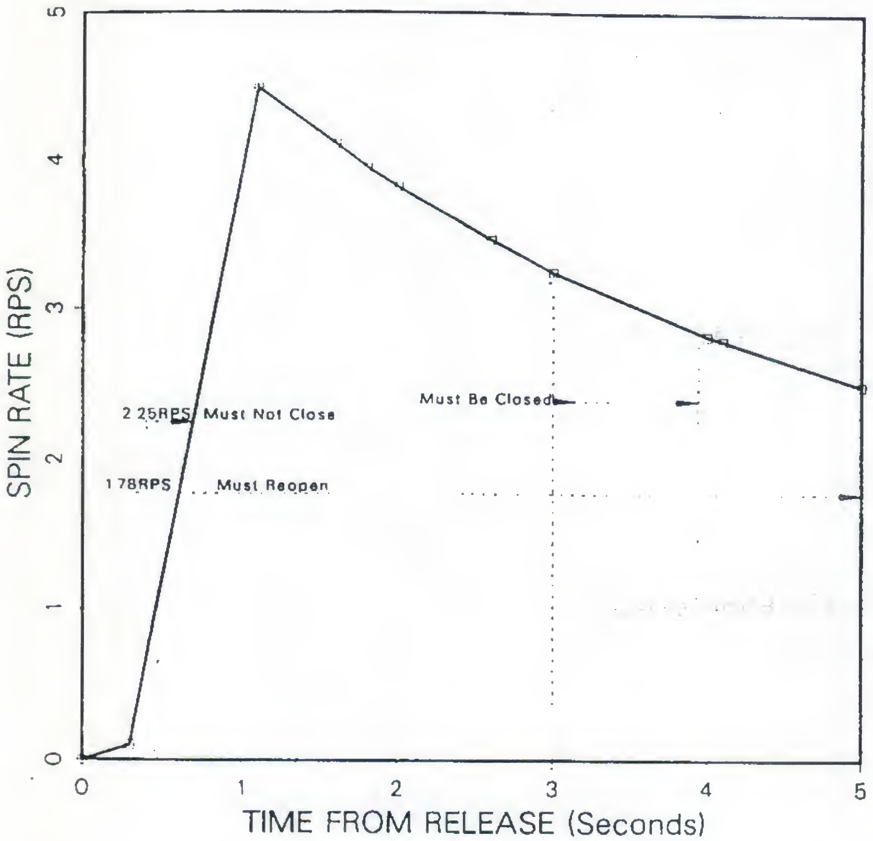


Figure 16. Functional Requirements for the Spin-sensing Rolamites, Minimum Spin Rate

case and to seal the electrical feedthroughs in the end caps. Each of the three rolamite switches contains a set of normally open contacts that close when adequate levels of acceleration are achieved. Both MC3671s are oriented to sense radial forces generated by the bomb rotation about its longitudinal axis in freefall delivery options. Each of the radial switches is electrically connected in series with one in the other MC4175 located diametrically opposite in the ECA. The MC3672 is installed longitudinally to sense deceleration in retarded delivery options. Figures 16 and 17 depict the operational requirements of the rolamites for minimum bomb acceleration levels in freefall and parachute retarded delivery modes.

The function of the rolamite switches in the MC4175 TSSG is to hold off power, either pulse battery (retard deliveries) or main battery (freefall deliveries), from the TUQS-producing electronics. The TUQS is "stored" in the electronics. As discussed below, the MC4137 TSSG does not "store" the TUQS; only by correctly interpreting and storing the IUQS can the MC4137 generate the TUQS. Storing the IUQS "enables" the MC4137 to generate the TUQS and hence is "intent-enabled."

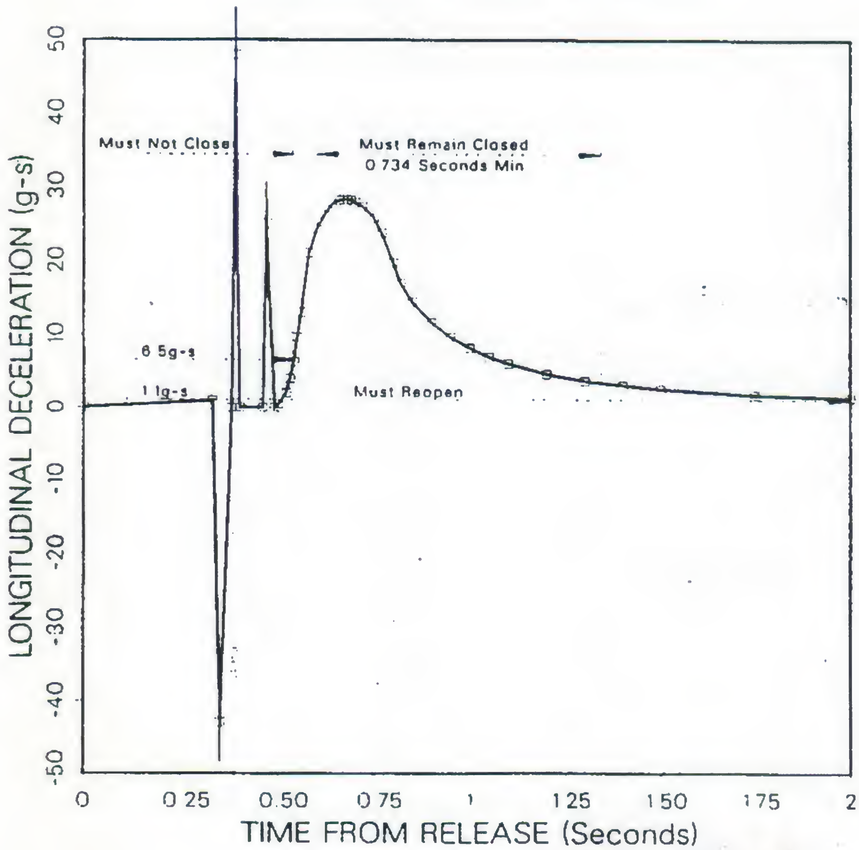
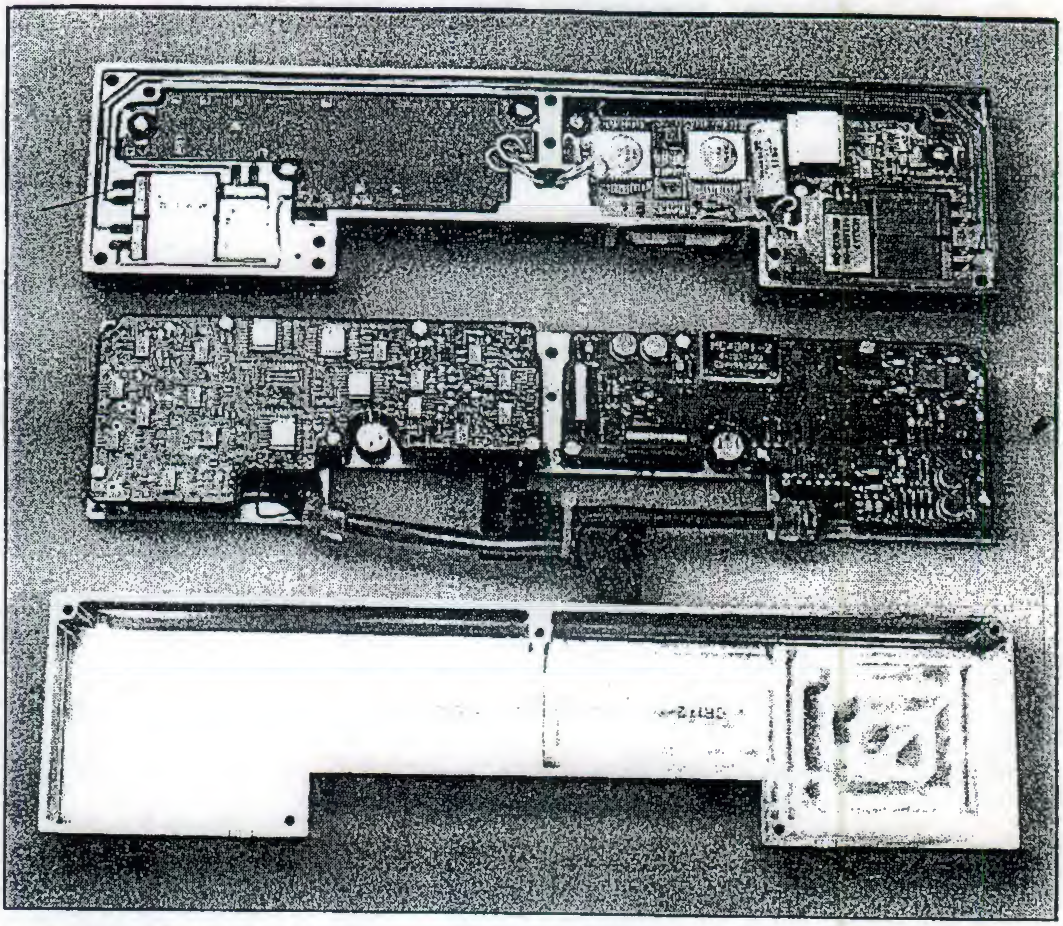


Figure 17. Functional Requirements for the Retard-sensing Rolamite, Minimum Parachute Retardation

MC4137 TSSG

The "intent-enabled" design of the MC4137 requires the MC4137 TSSG electronics to "store" the IUQS signal which enables (operates) the MC2969 Intent Strong Link Switch in the firing set during the prearming of the bomb before aircraft release. Until the MC2969 arming sequence is complete, the TUQS signal is not "stored" in the MC4137 electronics. Without the information content of the IUQS signal, the MC4137 cannot formulate the TUQS signal. The strong link/weak-link design and packaging of earlier B61 TSSGs is also retained. Additionally, the new MC4137 "intent-enabled" TSSG is philosophically improved over the earlier TSSGs designed for the B61. Discussion of the nuclear detonation safety of the two TSSG designs appears in Chapter 4.

Figure 18. MC4137 TSSG, Intent-enabled



During prearm of the bomb, the MC4137 TSSG will store the IUQS code in "volatile" memory; without power the code will not be retained. The design of the MC4137 will assure that the IUQS is retained for a minimum of 7 seconds of power loss. If all arming power and monitor power is lost for longer than 7 seconds, the MC4137 will interrupt the arm monitor line to the AMAC. On Navy System I aircraft (A-7E and F/A-18), this will result in both the "arm" light and the "safe" light being illuminated when power returns. On the FSA aircraft (A-4M, A-6E,G), the "disagreement" light will illuminate. A power dropout long enough to cause this condition will require the pilot to retransmit the IUQS to "rearm" the TSSG. Power dropouts of shorter duration will not affect the AMAC indications or cause additional pilot workload. The use of "volatile" memory for IUQS retention is a desirable nuclear safety design feature.

Although the B61-6,8 MCs only require compatibility with Navy strike aircraft, the MC4137 TSSG will be designed to be compatible with all aircraft approved for carriage of any B61. Additionally, all aircraft listed in the B90 MCs will be tested for compatibility during development. Demonstration of aircraft compatibility and subsequent incorporation in the B61 ACCD will be restricted to those listed in the MCs.

Whereas the MC4175 TSSG uses two identical, non-conductive assemblies to provide outputs to the two MC2935 Trajectory Strong Link Switches in the firing set, both channels of the MC4137 are packaged in a single conductive enclosure (Figure 18). The materials selected are 304 stainless steel for exclusion region protection and 6061 aluminum for the cover. The single housing is designed to maintain mechanical integrity of the housing, rolamites, and exclusion area electronics in abnormal environments. Isolation of all signals from the case is required.

The top assembly in Figure 18 is the exclusion region containing the rolamites, weak-link ROM, and the circuitry necessary to communicate the ROM pattern through the rolamite contacts to the microprocessor. The circuit board is ceramic. The circuit boards in the middle of figure 18 are identical, with surface mount components on one side (left) and leaded, "through-hole" components on the other. This circuitry is mounted to the steel top of the exclusion region and lies beneath the aluminum cover.

Two new rolamites are in development; the MC4146 to sense bomb spin and MC4147 for retard deliveries. Both are steel-case, hermetically sealed assemblies. As in the MC4175, the spin rolamites are connected in series between the two channels and are diametrically opposed in the bomb to require true spin of the bomb. The new rolamites are approximately two-thirds the size of the MC3671/3672 rolamites and designed for increased ruggedness and predictability in abnormal high shock environments. Since the rolamite case and the band is electrically grounded to the TSSG case, the contact block in the roller is isolated from the roller and the band. The required electrical path is through the pins and the contact block. Figure 19 illustrates the "rest" position of the rolamite (top and side views). The band of each rolamite is designed to fail in a predictable manner in very high shock levels. Figure 20 shows the resultant position of the rolamite after sustaining a shock sufficient to break the rolamite band. Note the contact block is welded to the band, not to the roller. The resultant failure position of the band after a very high shock is repeatable and illustrates the safety of the design. To fail armed, the isolated contact block would have to provide an electrical path through the pins. Previous rolamite designs (including the MC3671/MC3672) have used electrically-isolated materials for the cases and utilized the band as the conductive path between the input and output pins. Shorting through the band of the MC4146 and MC4147 will shunt the signal to ground. The contact block assembly provides the only means of an electrical path from input pin to output pin internal to the rolamite. Figure 21 provides another illustration of the "rest" and "actuated" rolamite states and the resultant position after a high shock has failed the rolamite band.

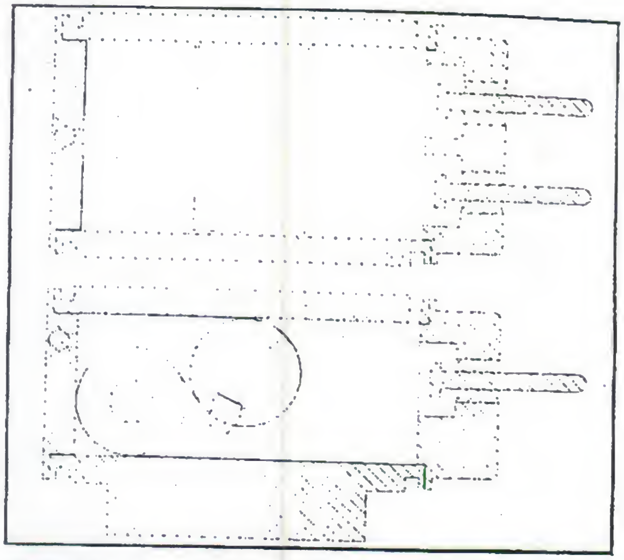


Figure 19. MC4146/MC4147 Rolamites, "Rest" Position

Figure 20. MC4146/MC4147 Rolamites, "Safe" Band Failure

To format the TUQS signal, MC4137 TSSG will combine 24 bits of the IUQS signal with 24 bits stored in a thermal weak-link ROM (read only memory) currently in development. Low melt alloy loops on a printed circuit board (Figure 18) form the 24 bits of the ROM. Melting of the "loops" in high temperatures from abnormal environments will result in either opening or shorting to the board. Either alternative is "safe"; combining the weak-link ROM and the IUQS signal will lock up the MC2935 TSLS.

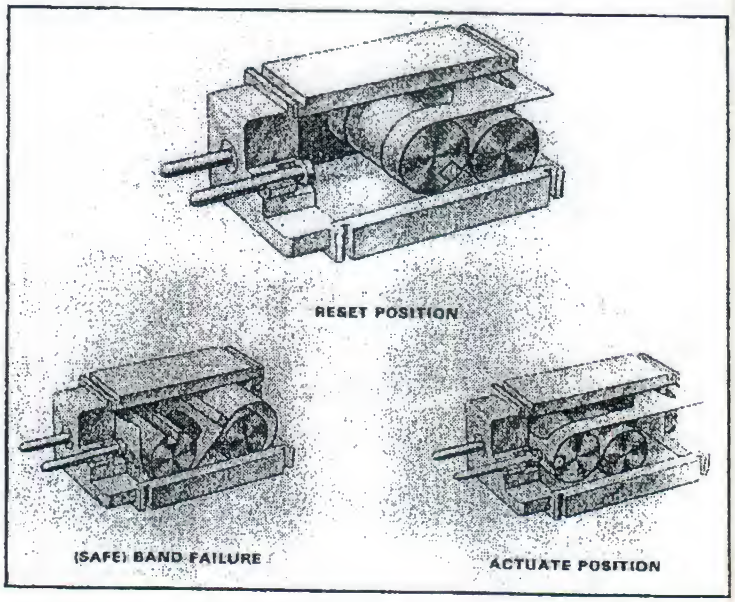


Figure 21. MC4146/MC4147 Rolamites

Main Battery and Cable Assembly

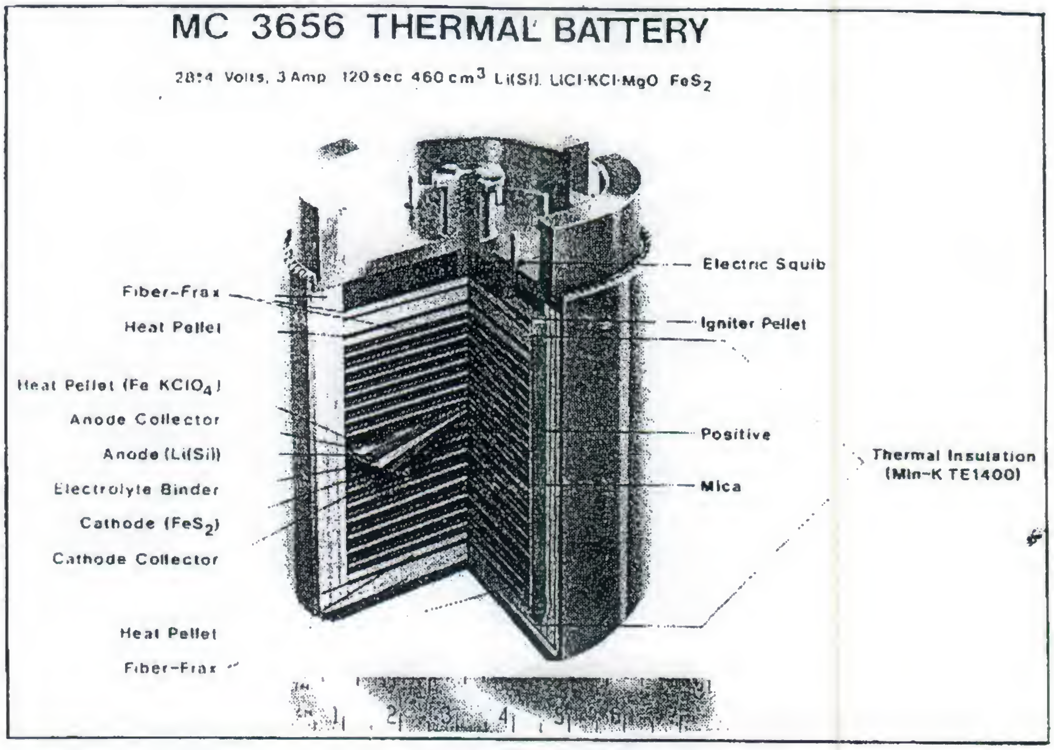


Figure 22. MC3656 Main Battery

The battery and cable assembly consists of the MC3656 Main Battery[26] (Figure 22) mated with an integral cable (Figure 23) and is identical to that used in the B61-7. Two each are used in the B61-6,8, one per channel. The MC3656 is a low-voltage thermal battery used to supply power to the electrical system beginning no later than 1.7 seconds from initiation and lasting for a minimum of 120 seconds. Lithium-silicon/iron disulfide (Li(Si)/FeS_2) electrochemical system is used. Lithium-silicon alloy is the anode and iron disulfide is the active cathode material. As in all thermal batteries, a fused salt electrolyte is activated by heating it to a temperature above the electrolyte's melting point using a pyrotechnic heat source. An MC2046 Igniter (1-A no-fire) fired by the MC4138 Programmer is used to activate the pyrotechnic.

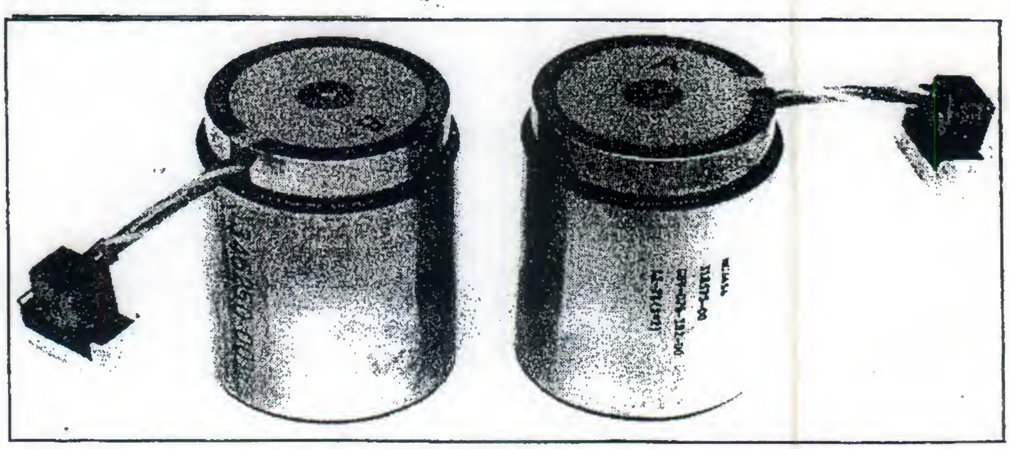


Figure 23. Battery and Cable Assemblies

MC4139 Junction Box

The MC4139 Junction Box (Figure 24) serves as a junction and distribution box for a major portion of all arming, fuzing, and firing signals. All electrical connections between the center case, the preflight, and tail subassemblies are made through the junction box.

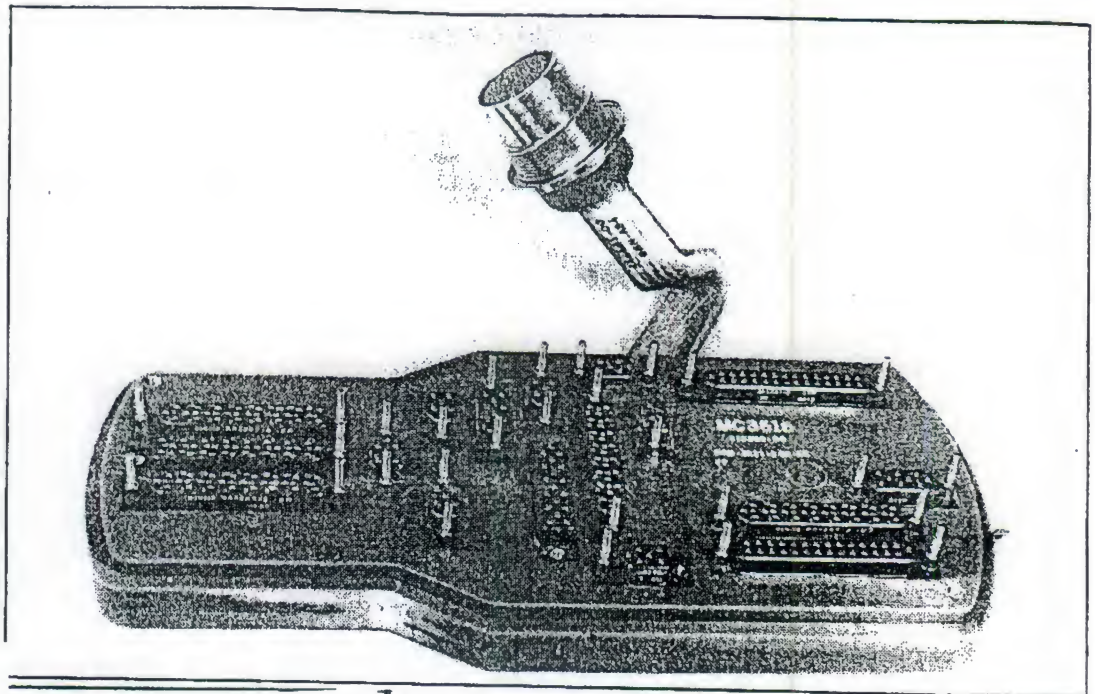
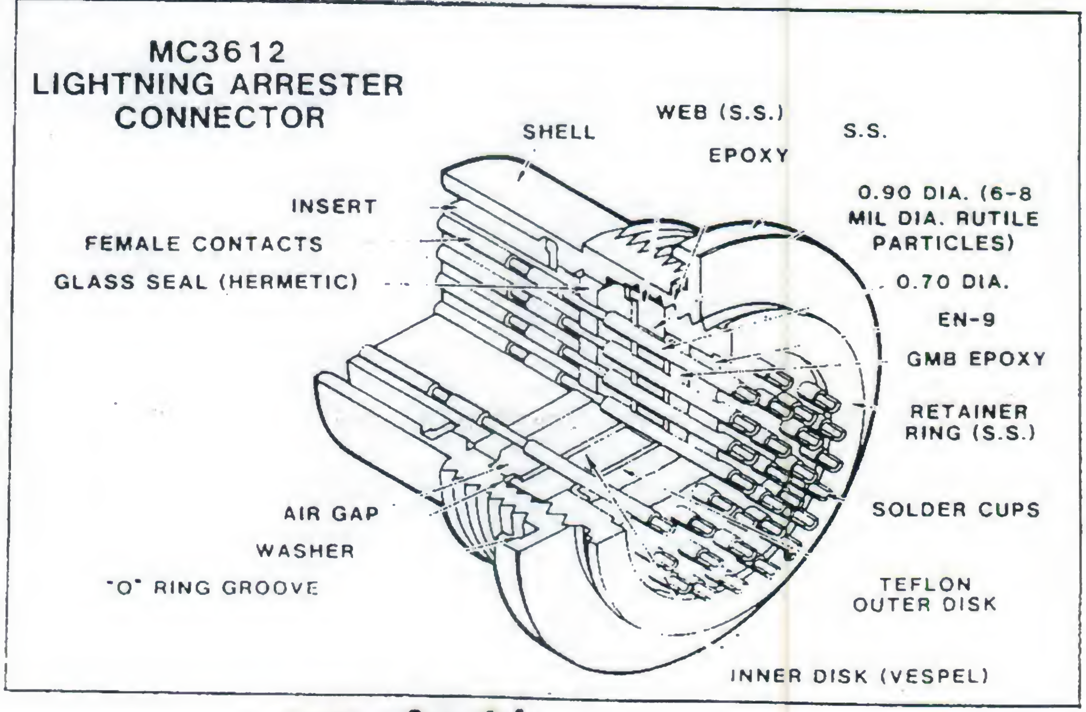


Figure 24. MC3616 Junction Box

single multilayer circuit board that electrically interconnects with 11 SA1387-type rack-and-panel connectors and 2 SA1530 double-density rack and panel connectors. A molded cable terminated with an MC3612 Lightning Arrestor Connector (LAC) is also attached to the junction box. This assembly is encapsulated in mica-filled epoxy.

The MC3612 LAC[25] (Figure 25) is a 41-pin rutile particle (TiO_2) design. The LAC features are fabricated into an SA3016 connector shell which is an extended version of the hermetically sealed, stainless steel, SA1457 connector. A stainless steel web with holes for each connector pin is used to provide a small air-gap between the pins and the return path. The air-gap around all pins is filled with rutile particles and then sealed. This assembly gives a nominal breakdown voltage of 1000 V and a maximum acceptable breakdown voltage of 1350 V when tested with a 10-kV/μs pulse

Figure 25. MC3612 Lightning Arrestor Connector



MC4140 Interface Control Unit

The MC4140 Interface Control Unit (ICU) is a microprocessor-based component (Figure 26) housed in a hermetically sealed stainless steel container identical to that of the MC3638 ICU used on the B61-7 (Figure 27). The ICU is mounted on the aft surface of the center case cover plate. Cables from the ICU interconnect with the MC3624 Filter Pack, the MC4136 PFC, and the MC3612 LAC pigtail on the MC4139 Junction Box. Each electrical connector is hermetically sealed. Both the programmer and ICU use the same Intel 80C51 microprocessor. The ICU has functional requirements while on-board the carrier aircraft and after release of the bomb. While on-board the aircraft, the ICU is designed to provide:

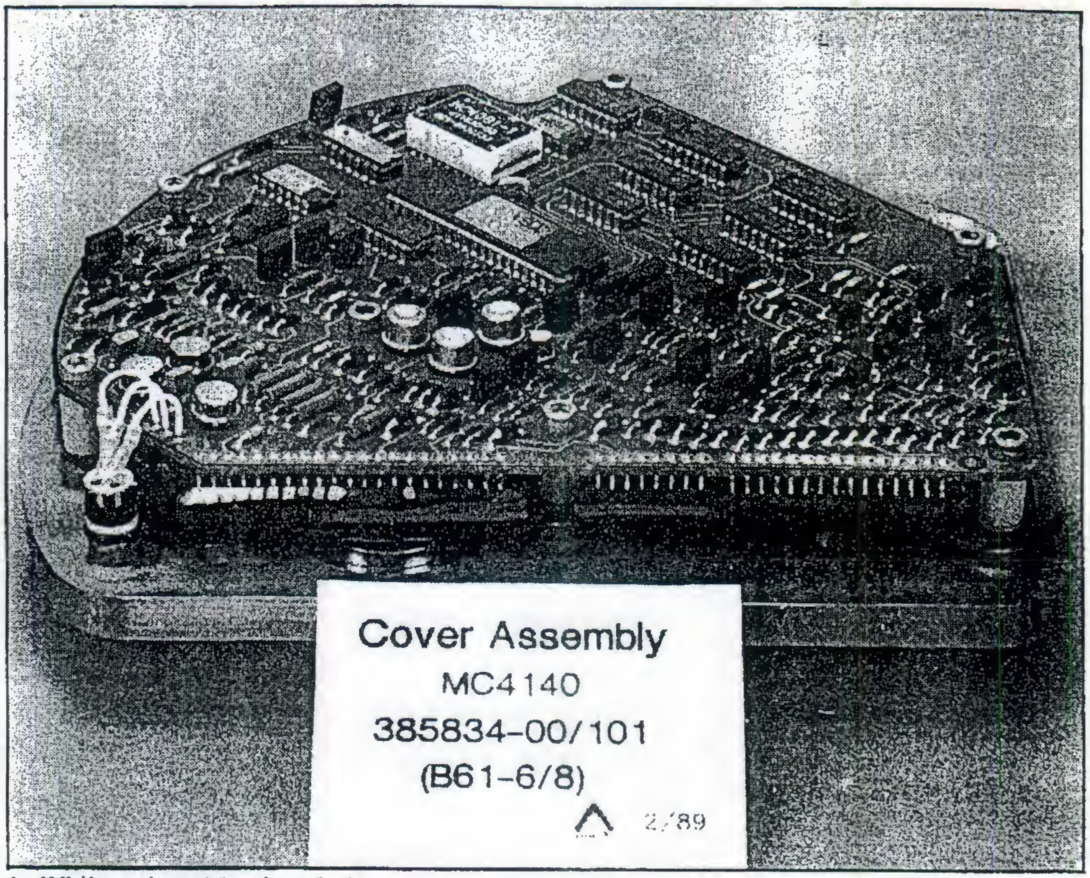
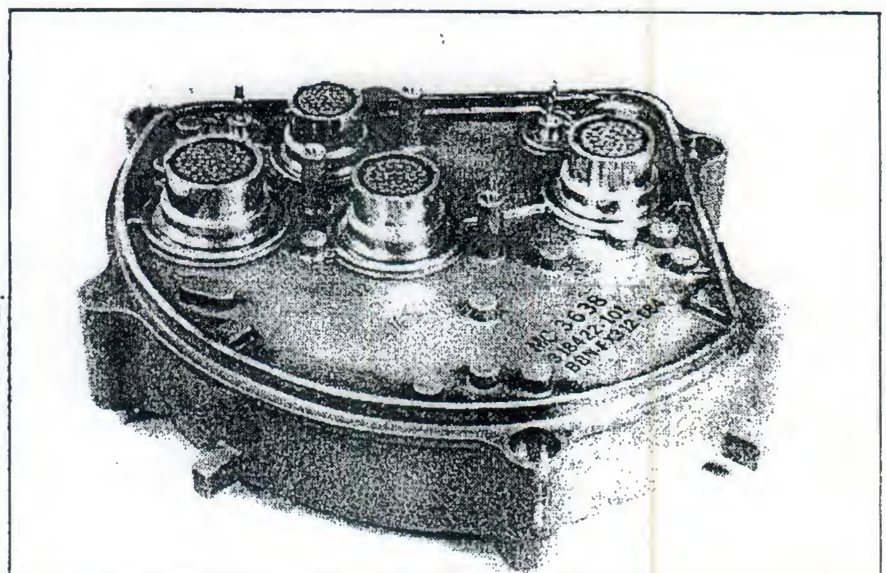


Figure 26. Cover Assembly of the MC4140 Interface Control Unit

a. Logic Monitor - Circuitry necessary to monitor the state of the MC2969 Intent Stronglink Switch (enabled, safe) and provide the proper response to both FSA and System 1 aircraft AMAC circuits. Additionally, an interface with the MC4137 TSSG is provided to assure feedback to the aircraft in case of power dropouts.

b. Delivery Mode (FFA, FFG, REA, or REG)- ICU circuitry stores the intended delivery mode as selected from the aircraft (System 1 AMACs) or the aircraft and the MC4136 Preflight Controller (FSA/B AMACs).

Figure 27. MC3638 ICU



d. Safe Separation Time (SST) Selection - Two independent SSTs, TA and TB are set on the preflight controller. Some AMACs can select between TA or TB. The ICU is designed to store and use this information.

After bomb release, the MC4140 is without power until the rise of the weapon system pulse batteries. [redacted] The remaining function of the ICU is to perform the timing and "gate" pulse battery power to initiate the spin rocket or gas generator. After the "deploy" function, the ICU tasks are complete and "shutdown" is commanded.

DoE/DoD b(3)

MC4136 Preflight Controller

[redacted] The preflight controller also houses the DE1002 Coded Device and MC3246A Thermal Battery (identical to the MC3246[26] in the B61-7 except lithium-silicon/iron disulfide (Li(Si)/FeS_2) electrochemical system is used) for command disable, the J1 connector for PAL operations or interconnecting with the MC4142 Strike Enable Plug, and the PAL voltage regulator. The command disablement and PAL components are described in Chapter 6. The preflight controller is mounted to the preflight bomb subassembly case.

DoE/DoD b(3)

The switch markings and function associated with each switch position are as follows:

TA and TB - For non-laydown deliveries, two independent aircraft safe escape times (TA and TB) are selected. The selection of each requires the manipulation of two digital switches, one for the tens data (1-10) and one for units data (0-9). The maximum safe escape time for the B61 is 69 seconds; therefore, the 7, 8, 9, and 10 switch positions of the tens switch are shorted to the 6 switch deck. Thus, 109 becomes 69, 77 becomes 67, etc. No provision is made to prevent TB settings shorter than TA or vice versa. The selection of the appropriated safe escape time is made from the aircraft during bomb prearm.

Delivery - 2 position; RE,FF

RE - retarded

FF - freefall

Aircraft with FSA AMACs like the Navy A-6E can not override this switch. Arm position selections on the AMAC are limited to AIR and GROUND. System 1 AMACs like the Navy A-7 and A-18 can override this switch; all four delivery options are selectable from the cockpit.

[redacted]

Delay - 3 position; G, H, J

G — 0.3 second deployment delay

H — 0.6 second deployment delay

J — 1.6 second deployment delay

Additionally, positions G and H provide short laydown delay (30 seconds) and position J provides long laydown delay (80 seconds) for aircraft safe escape from laydown deliveries. Discussions at the B61 POM and the B61 Environmental Sugroup have recently addressed the use of "J" by Navy aircraft. Future B61 ACCDs may restrict the use of longer delay times than compatibility tests and analyses have shown to be sufficient to provide separation. No settings longer than the "minimum" times now specified in the ACCD will be approved.

[redacted]

DoE b(3)

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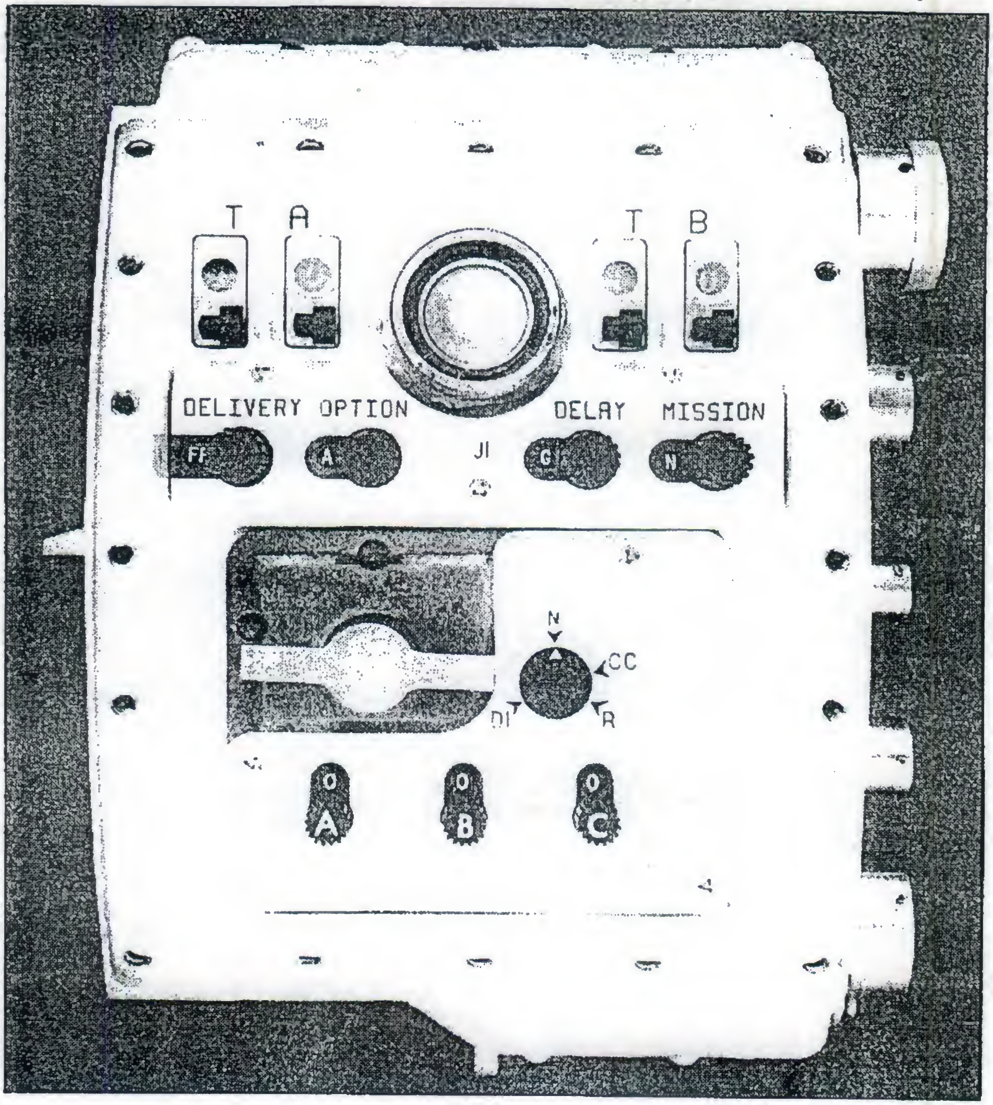

Figure 28. MC4136 Preflight Controller

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MC2213 Actuator and Pulse Battery Assembly

The MC2213[27] (Figure 29) consists of two MC2238A[28] or MC2238B Pulse Batteries, an MC2217 Pullout Switch, and a capacitor-resistor network. Aircraft power is required before release to charge the capacitor network. When extraction occurs, the MC2217 Switch completes the circuit to apply the capacitor-stored energy to the electric matches of the MC2238A/B Pulse Batteries. The MC2238 Pulse Batteries, depicted in Figure 29, will be replaced by MC2238A or MC2238Bs (Figure 30) that are designed and tested to the greater electrical load of the B61-6,8. Resistors are provided to bleed off the charge in less than two seconds if arming power is removed.

The MC2238A/MC2238B Pulse Batteries supply power to the bomb electrical system until the MC3656 Main Batteries reach operating voltage. The pulse batteries are required to provide source power to the ICU (including spin rocket or parachute initiation), programmer (including the main battery initiation), and the TSSG to drive the MC2935 Trajectory Stronglink Switches in retard delivery options.

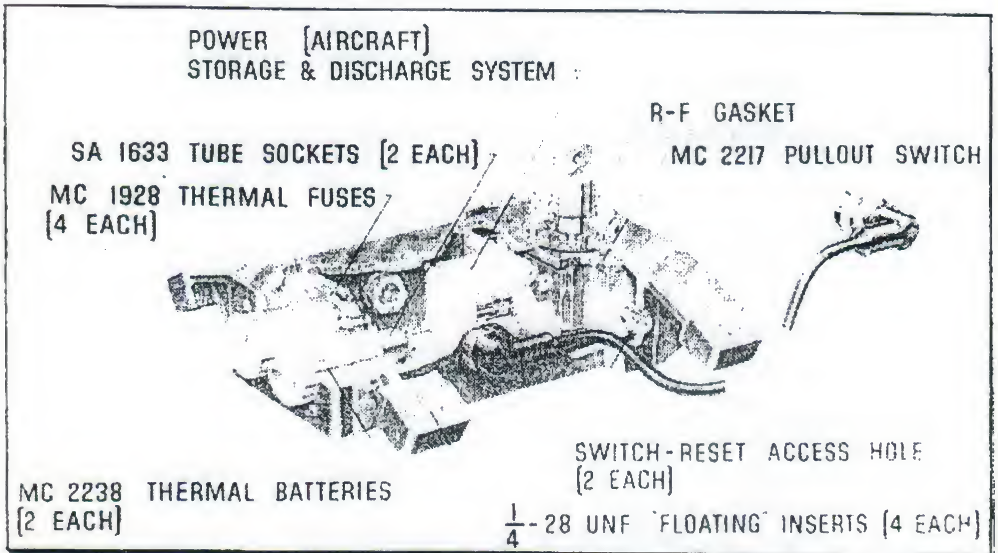

Figure 29. MC2213 Actuator and Pulse Battery Assembly

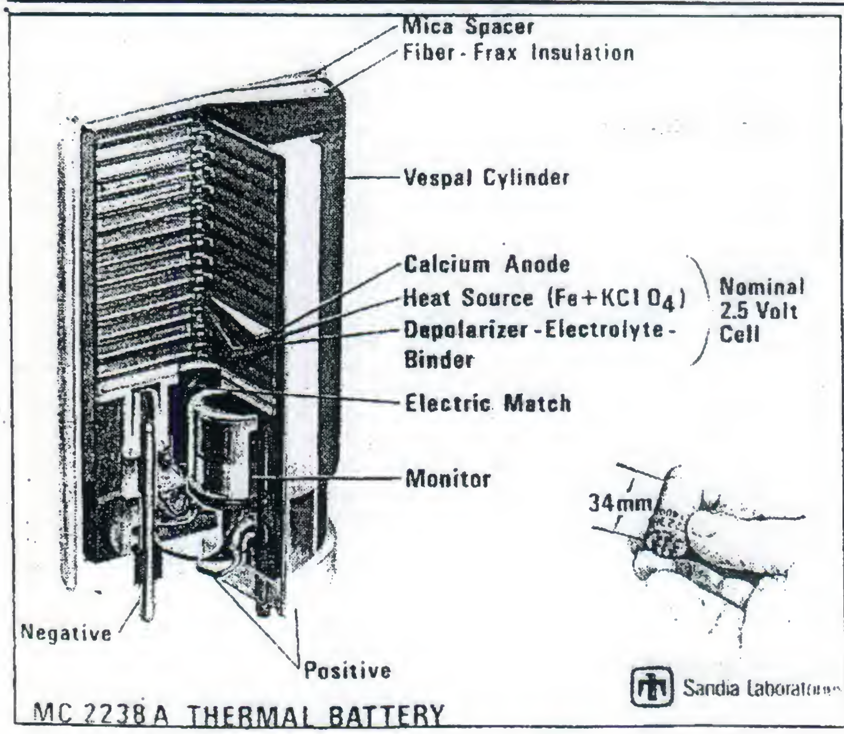

Figure 30. MC2238A Thermal Battery

MC3624 Filter Pack

The function of the MC3624 Filter Pack[29] (Figure 31) is to attenuate aircraft-wiring-induced EMR/EMP signals and to provide an electrical connector for aircraft interfacing. The MC3624 is housed in an aluminum casting that is attached to the inside surface of the tail subassembly. A long junior trilock (LJT)-type connector protrudes through a hole in the tail subassembly for aircraft electrical interfacing. Inside the aluminum housing are filters that perform the EMR/EMP attenuations. The MC3624 is used in the B61-7.

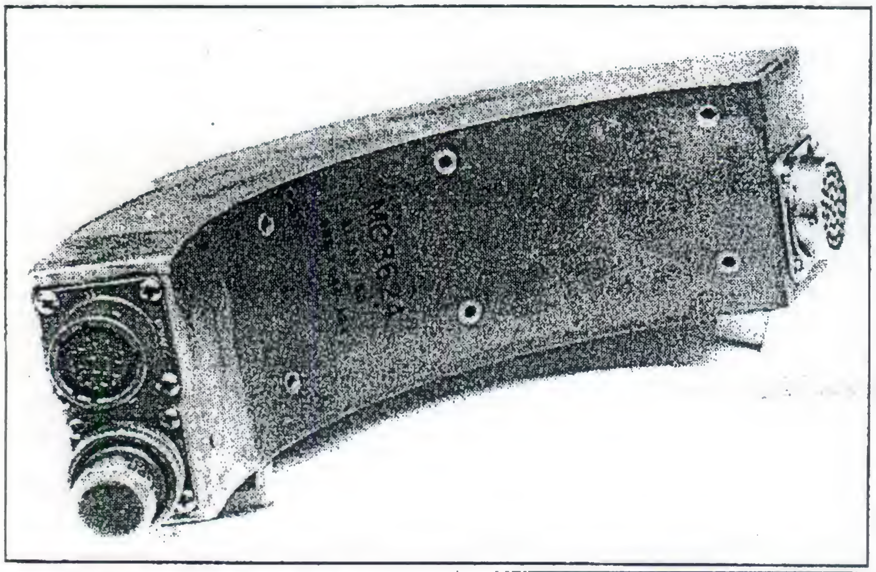

Figure 31. MC3624 Filter Pack

MC3025 Signal Selector

The MC3025 Signal Selector, sometimes referred to as the "normal/override switch" is an IUQS-generator combined with a manually operated two-position switch (Figure 32). The purpose of the MC3025 is to supply the IUQS to drive the MC2969 Intent Strong Link Switch in the firing set to complete the prearming operation when the AMAC in the aircraft is not IUQS-capable. At the present time, the Navy A-4M, A-6E, and A-7E aircraft do not have IUQS-capable AMAC's. There is a high level DoD/DOE agreement[30] that all aircraft will be equipped with IUQS-capable AMAC's by 1 January, 2000. By that time all MC3025's will be removed from the B61-6,8.

The MC3025 was developed for the B61-5 (FPU June 1977) and was subsequently used in the B61-3,4. Since May 1988, new production B61-3,4 have not incorporated MC3025 Signal Selectors. Removal of the MC3025 from the B61-3,4 will begin in 1989. These signal selectors will be used in the B61-6,8.

The switch positions are designated NORMAL and OVERRIDE. Two independent mechanical motions, linear and rotational, are required to change switch positions. In the OVERRIDE position, the switch allows prearm power to be applied to the input terminals of the intent unique signal generator in the MC3025. With the MC3025 in OVERRIDE, the nuclear detonation safety of the B61-6,8 is reduced. The nuclear detonation safety requirement in abnormal (accident) environments and the nuclear safety concerns of the MC3025 are addressed in Chapter 4.

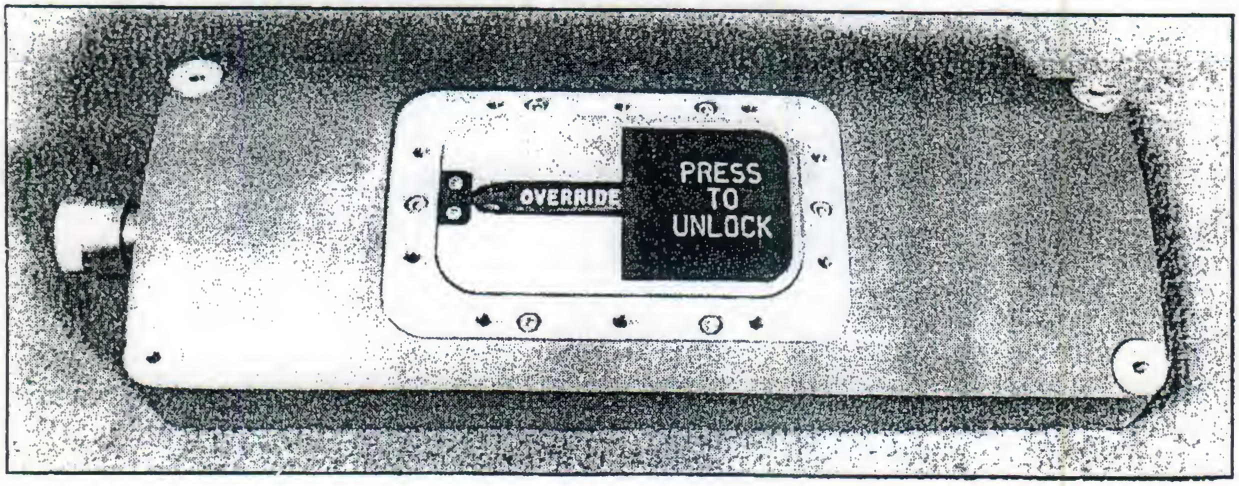

Figure 32. MC3025 Signal Selector

Cables

Some cables from the parent weapon will be reused for the B61-6,8. These include the radar and nitrogen cartridge cables inside the center case from the B61-0,2,5 and the deployment initiation cables to the gas generator and spin rocket inside the preflight subassembly from the B61-5 only. There are six new-design cables identified by CF-numbers; four in the center case and the one between the preflight and tail sections. In addition, the build of the B61-6,8 will require ten new, carryover-design cables; however, five of these cables are part of a "parent" B61-5 and are not necessary for a B61-5 to B61-8 conversion. All cables are constructed of teflon-insulated conductors within a polyurethane or kapton sleeving. Three connector types are used: junior trilock (JT), long junior trilock (LJT) with rigid inserts, and rack and panel. The table below summarizes the B61-6,8 cable requirements.

Cables for B61-6,8

	Parent Bomb	—New Build— Carry-Over	New Design	CF
Radar-JB	√			1805
N_2-JB	√			1804
Gas Gen		(61-5)		2241
SpinRocket		(61-5)		2240
FP-MC3025		(61-5)		2262
FP-ICU		√		2638
ICU-PFC		√		2636
ICU-PFC		√		2637
ICU-LAC		√		2635
FP-PFC/ETU			√	2940
JB-Firing Set		√		2654
[redacted]				
JB-Disable			√	2908
FiringSet-NG			√	2906
FiringSet-NG			√	2907
Pullout		(61-5)		2233
Pullout		(61-5)		2438

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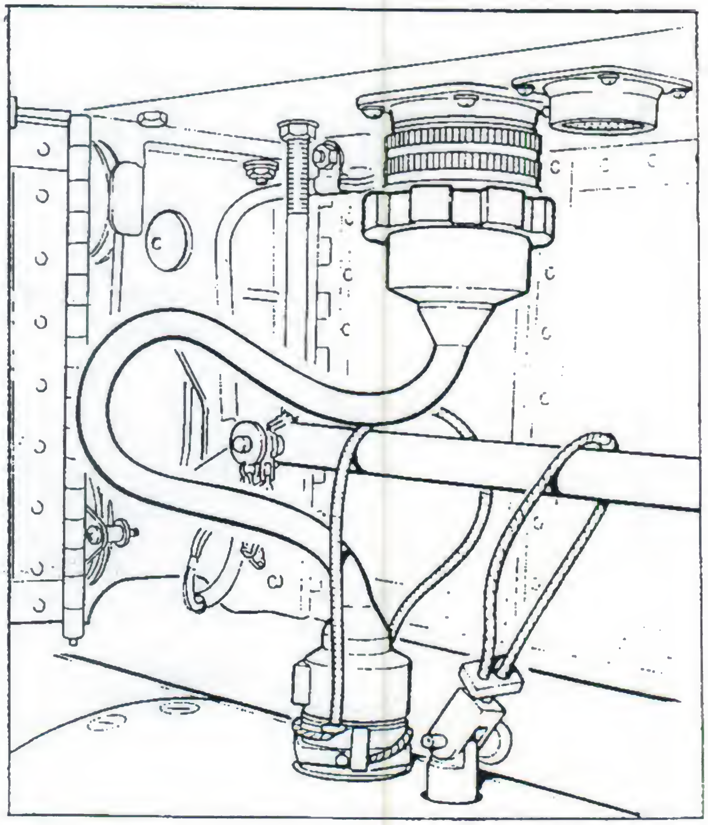
Figure 33 illustrates a B61-6,8 aboard a typical Navy aircraft and shows the CF2233 or CF2438 Pullout Cable and pullout lanyard hook-ups. Both pullout cables are EMR-protected cables that provide electrical interfacing between the B61-6,8 and the carrier aircraft. The CF2233 will be used with FSA AMAC aircraft like the A-4M and A-6E,G while the CF2438 will be used with System 1 AMAC aircraft like the A-7E and F/A-18. Both connectors of the CF2438 are identical types and could be reversed. The differences in the physical appearance (Figure 33) should preclude that occurrence.

MC4142 Strike Enable Plug

The MC4142 Strike Enable Plug attaches to the J1 connector on the MC4136 Preflight Controller. To meet the MC requirement for a separable component "vital to the function of the bomb," the SEP provides two circuit interruptions; IUQS and the nuclear identification line from the AMAC.

Figure 33. B61-6,8 Aircraft Interface



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3. System Operation

General

Preflight operations and arming, fuzing, and firing events for the four bomb delivery options are discussed in this chapter. A simplified functional block diagram (Figure 34) and pictorial event sequences for each bomb delivery option (Figures 35-38) are included. Those procedures and electrical system operations that are common to each delivery option are presented below.

Before takeoff, the appropriate switch settings are made on the MC4136 Preflight Controller as described in Chapter 2. At this time, the PAL could be unlocked through the J1 connector of the MC4136 with ground equipment (Chapter 6) or after takeoff if the aircraft is equipped with a PAL-capable AMAC. Complete bomb prearming cannot be accomplished until the PAL is unlocked (i.e., enabled). The MC4142 Strike Enable Plug would be installed. If the aircraft does not contain an IUQS-capable AMAC, the MC3025 Signal Selector must be rotated to the OVERRIDE position.

The bomb may now be prearmed before release by rotating the AMAC selector switch to the desired option position. On FSA/B AMACs, this selector switch provides two positions: air or ground. Retard or freefall is obtained by the delivery switch position on the preflight controller. On System 1 AMACs like the A-7E and F/A-18, the AMAC has four positions corresponding to the four delivery options: FFA, FFG, REA, and REG. With this capability, the RE/FF Delivery Switch on the MC4136 PFC is overridden.

The F/A-18 AMAC generates a unique train of pulses (IUQS) to drive the MC2969 Intent Stronglink Switch to the closed (enabled) position. Without the AMAC-produced IUQS, the MC2969 will be enabled by the MC3025 Signal

Figure 34. B61-6,8 Functional Block Diagram

DOE b(3)

Selector (in OVERRIDE) with dc-prearm power when the AMAC is rotated to an ARM position. The MC4137 TSSG stores the IUQS. On another line, the AMAC applies prearm power to charge the capacitors in the MC2213 Actuator and Pulse Battery Assembly.

At bomb release, the CF2233 (FSA aircraft) or CF2438 (System 1 aircraft) Pullout Cable and the pullout pin of the MC2213 are extracted via the bail and lanyard from the bomb (Figure 31). There is not a requirement to extract the lanyard pullout pin before the bail pullout cable. The "soft" memory circuits of the MC4140 ICU are designed to be without power from the earliest pullout cable extraction to the latest pulse battery rise. At pullout, the MC2213 discharges the capacitive network through the closed switch contacts into the MC2238A/B Pulse Battery ignitors.

When the pulse battery rises to a nominal 19 V (~80 ms), both the MC4138 Programmer and the MC4140 ICU begin timing and each microprocessor starts its instruction set. The programmer checks the source of power, pulse battery or main battery ("shutdown" is commanded if the power source is the main battery — an abnormal situation), and at approximately 50 ms begins interrogating the ICU.

For personnel and nuclear detonation safety discussed in Chapter 4, the ICU commands "shutdown" if delivery option information is missing.

After receipt of the interrogation data, the programmer "gates" (or "connects and then disconnects") pulse battery power to initiate the main battery ignitors. The sole remaining function of the ICU after answering the programmer's interrogation is to "gate" pulse battery power at the selected deployment time (G,H,J) to initiate either the gas generator (retard deliveries) or spin rocket (freefall). Having completed its requirements, the ICU microprocessor is held in a "shutdown" mode where no further outputs are possible.

At this point in the operational sequence, the main batteries' voltage is rising and will be at operating voltage before first possible ground impact in REG (laydown), the programmer has received all inputs from outside the center case (except for radar or crystal signals), and the spin rocket or gas generator has been initiated. Completion of the fuzing and firing operations will be described for each bomb delivery mode.

Freefall Airburst (FFA) Delivery

Upon initiation of the spin rocket, the bomb spins to a minimum roll rate of about 3 revolutions per second within about 1 second (Figure 35). The canted fins will sustain the roll rate. This roll rate closes the radial inertial switches (rolamites). At 3 seconds after release, the programmer "gates" main battery power to the MC4175 or MC4137 TSSG to drive the MC2935 Trajectory Stronglink Switch in the firing set (dual channel).

The aircraft-selected safe separation time (SST) has been previously communicated by the ICU to the programmer. At 7 seconds before SST, the programmer "gates" main battery power to the radar and at 4 seconds before SST, the programmer activates circuitry to communicate height of burst selection to the radar.

At safe separation time minus 3 seconds, the programmer connects main battery power to the transverter oscillator in the firing set (A1). At safe separation time, similar programmer circuitry connects main battery power to the firing set transverter (A2). With these two inputs, each electronic transverter can charge the 2.0-μF firing set X-unit capacitor and the 0.6-μF neutron generator capacitors to approximately 3300 V and 2400 V, respectively, in less than 1.2 seconds.

DOE b(3)

DOE b(3)

Figure 35. Event Sequence, Freefall Airburst

At safe separation time plus 1.5 seconds, programmer fire circuitry is enabled. Once this occurs, any subsequent radar fire signal will result in the programmer providing closure of the main battery to firing set (A3), causing X-unit discharge which initiates the neutron generator timing circuitry and fires the nuclear primary detonators.

If backup fuzing is selected, at SST plus 1.5 seconds the programmer will also accept impact crystal signals as valid fire signals. If neither radar nor crystal signal is received, the programmer will provide A3 at 120 seconds (design life of the main batteries). If backup fuzing is not desired, the programmer will not deliver A3 if impact crystal signal is received. Contact preclude is not guaranteed. If the bomb impacts the ground with a charged firing set, the X-unit may be triggered by the impact (bypassing the programmer), even if backup were not desired.

Figure 36. Event Sequence, Freefall Groundburst

Freefall Groundburst (FFG) Delivery

Upon initiation of the spin rocket, the bomb spins to a minimum roll rate of about 3 revolutions per second within about 1 second (Figure 36). The canted fins will sustain the roll rate. This roll rate closes the radial inertial switches (rolamites). At 3 seconds after release, the programmer "gates" main battery power to the MC4175 or MC4137 TSSG to drive the MC2935 Trajectory Stronglink Switch in the firing set.

The aircraft-selected safe separation time (SST) has been previously communicated by the ICU to the programmer.

At safe separation time minus 3 seconds, the programmer connects main battery power to the transverter oscillator in the firing set (A1). At safe separation time, similar programmer circuitry connects main battery power to the firing set transverter (A2). With these two inputs, each electronic transverter can charge the 2.0-μF firing set X-unit capacitor and the 0.6-μF neutron generator capacitors to approximately 3300 V and 2400 V, respectively, in less than 1.2 seconds.

At safe separation time plus 1.5 seconds, programmer fire circuitry is enabled. Once this occurs, the subsequent crystal fire signal will result in the programmer providing closure of the main battery to the firing set (A3), causing X-unit discharge which initiates the neutron generator timing circuitry and fires the nuclear primary detonators.

[redacted]

DOE b(3)

Figure 37. Event Sequence, Retarded Airburst

Retarded Airburst (REA) Delivery

Firing the gas generator into the volume enclosed by the telescoping tubes starts the parachute deployment process (Figure 37). The deceleration produced by the deployed parachute closes the longitudinal nonlatching inertial switch (rolamite). The design of the rolamite guarantees a closure time greater than the maximum required (0.734 seconds) for the MC4175 or MC4137 TSSG to enable the MC2935 Trajectory Stronglink Switch in the firing set.

The aircraft-selected safe separation time (SST) has been previously communicated by the ICU to the programmer. At 7 seconds before SST, the programmer "gates" main battery power to the radar and at 4 seconds before SST, the programmer activates circuitry to communicate height of burst selection to the radar.

[redacted]

DOE/DOD b(3)

[redacted]

DOE/DOD b(3)

At safe separation time minus 3 seconds, the programmer connects main battery power to the transverter oscillator in the firing set (A1). At safe separation time, similar programmer circuitry connects main battery power to the firing set transverter (A2). With these two inputs, each electronic transverter can charge the 2.0-µF firing set X-unit capacitor and the 0.6-µF neutron generator capacitors to approximately 3300 V and 2400 V, respectively, in less than 1.2 seconds.

If backup fuzing is selected, at SST plus 1.5 seconds the programmer will accept either a radar fire or impact crystal signal as a valid fire signal. Activation of the impact crystal at parachute-retarded terminal velocities (80 fps) will not be reliable in all terrain. If neither radar nor crystal signal is received, the programmer will provide A3 at 120 seconds (design life of the main battery).

Figure 38. Event Sequence, Retarded Groundburst (Laydown)

Retarded Groundburst (REG) or Laydown Delivery

Firing the gas generator into the volume enclosed by the telescoping tubes starts the parachute deployment process (Figure 38). The deceleration produced by the deployed parachute closes the longitudinal nonlatching inertial switch (rolamite). The design of the rolamite guarantees a closure time greater than the maximum required (0.734 seconds) for the MC4175 or MC4137 TSSG to enable the MC2935 Trajectory Stronglink Switch in the firing set.

For the laydown delivery mode, the safe separation times selected on the preflight controller do not apply. Aircraft safe escape maneuvers are instead constrained by the laydown delay time, which is 30 seconds or 80 seconds. Selection of G or H deploy time results in a 30-second delay, whereas J provides an 80-second delay. As discussed earlier, selection of J may be restricted in the B61 ACCD except for aircraft requiring that time to ensure safe escape.

At safe separation time minus 3 seconds, the programmer connects main battery power to the transverter oscillator in the firing set (A1). At safe separation time, similar programmer circuitry connects main battery power to the firing set transverter (A2). With these two inputs, each electronic transverter can charge the 2.0-µF firing set X-unit capacitor and the 0.6-µF neutron generator capacitors to approximately 3300 V and 2400 V, respectively, in less than 1.2 seconds.

At safe separation time plus 1.5 seconds, the programmer will provide closure of the main battery to firing set (A3), causing X-unit discharge which initiates the neutron generator timing circuitry and fires the nuclear primary detonators.

4. Nuclear Safety

General

This chapter summarizes the B61-6,8 nuclear safety design and evaluation program. The intent of the nuclear safety design is to assure that when the B61-6,8 is exposed to normal or abnormal (accident) environments, there is a probability of less than 1 in 10^9 or 1 in 10^6, respectively, that its TNT equivalent yield will not exceed four pounds.

[redacted]

Nuclear safety requires isolation of all significant voltages from key components within the firing set and from nuclear system detonators, thus precluding simultaneous detonator function. This isolation must be assured for all normal and abnormal environments except for authorized use. Although the B61-6,8 contains internal power sources, these sources are limited to a maximum terminal voltage of less than 50 V. Safety analyses conservatively assume these power sources to be activated in all abnormal environment scenarios.

System nuclear safety evaluation is accomplished both by analysis and by testing to verify the predicted results. Included in this chapter are a description of the B61-6,8 nuclear safety design and a summary of the nuclear safety evaluation program to be performed. The limited number of fullscale tests scheduled as part of the B61-6,8 evaluation program is due to the applicability of B61-3,4 and B61-7 nuclear safety evaluations.

Design Theme

The following goals for achieving nuclear safety were established for the B61-3,4 and B61-7 development programs and are also applicable to the B61-6,8 design:

- Provide an assured, predictable safe response of the bomb in a broad range of accident environments, including fire, impact, crush, and puncture
- Provide a design that is insensitive to electrical faults in accident situations
- Provide a design that meets the nuclear safety requirements without requiring detailed definition of the abnormal environments.

The basic theme of the B61-6,8 nuclear safety design is to isolate nuclear safety critical circuits from all unintended sources of electrical energy. This theme is implemented through nuclear safety design concepts that include:

- Exclusion Regions — The important features of the exclusion region design concept are:
  - (a) consolidation of the safety-critical circuit elements into a localized region of the bomb,
  - (b) use of physical barriers between safety-critical elements and all energy sources that could cause the critical elements to function, and
  - (c) controlled access of intended electrical signals through the physical barriers by special unique-signal-operated devices that can be actuated only in the intended use mode.
- Stronglinks — Access to the safety-critical circuit elements contained within the exclusion regions is controlled by safety devices called stronglinks. These devices provide the only access for electrical energy into the associated exclusion region, which is completely enclosed by the physical barrier. In the B61-6,8, these devices are unique-signal-operated stronglink switches (MC2969 Intent Stronglink Switch and MC2935 Trajectory Stronglink Switch).
- Weak-links — A weak-link is a functional element, critical to the initiation of the nuclear system, and designed to fail irreversibly at environmental levels less severe than those which fail or bypass the stronglink devices and physical barriers.
- Colocation of Weak-links and Stronglinks — The weak-links and stronglinks are packaged in close proximity (colocated) within the exclusion region(s) so that they experience comparable environments. Since a weak-link is designed to fail at an environmental level well below the failure or bypass levels of stronglinks and barriers, the proper sequential response of these safety elements will occur in credible abnormal environments.
- Signal Incompatibility/Inoperability — Unique signal patterns are required to close the stronglink switches, which control electrical signal access to isolated exclusion regions. These features virtually eliminate the likelihood that typical electrical energy sources assumed to be present in an accident situation could drive these switches to a closed (unsafe) position.

Design

Implementation of the above design theme is expected to provide levels of safety assurance against premature nuclear detonation of 1 in 10^9 and 1 in 10^6 in normal and abnormal environments, respectively. Three independent safety subsystems have been designed into the B61-6,8 electrical system to satisfy the safety assurance levels for the environments defined in the B61-6,8 STS:

(1) Intent Safety Subsystem,

(2) Trajectory Safety Subsystem, and

(3) Arming Safety Subsystem.

Two of the safety subsystems, the intent and trajectory subsystems, constitute the abnormal environment safety design. Each independent system is composed of a unique signal generator (USG) and an associated unique-signal-operated stronglink switch. The stronglink switches are located within the MC2918 Firing Set. The intent and trajectory subsystems operate in series, with each expected to provide a safety assurance level of greater than 1 in 10^3. Together, they provide an assurance level of greater than 1 in 10^6 in normal and abnormal environments. The third subsystem, the arming subsystem, is intended to provide a safety assurance level of greater than 1 in 10^3 in normal environments only. The three independent systems together, then, provide a safety assurance level of 1 in 10^9 in normal environments. Figure 35 is a simplified schematic diagram of the pertinent mechanical features and electrical components involved in the B61-6,8 nuclear safety design.

The center case section contains the nuclear safety critical elements of the B61-6,8 and is designed to ensure electrical system survival and function following laydown impact on hard targets. As will be described in this section, the robust mechanical design for reliability, mitigates the effect of some abnormal environments. Center case components are enclosed within two metal housings. The outer case structure is a thick (0.534 in., 13.6 mm) aluminum extrusion containing the nuclear system and electrical components. This case is closed at the aft end with an aluminum cover plate secured with a ring which threads into the inner surface of the case. The only external point of entry for electrical energy through the cover plate is via the lightning arrestor connector.

[redacted]

MC2918

The MC2918 Firing Set is the electrical system safety design focal point for abnormal environments. The safety design concepts of exclusion region isolation, weak-link/stronglink element colocation, and unique-signal safety devices are implemented in the firing set. The exclusion regions are physically defined by cells in the firing set that are formed by the walls of the firing set container and the stronglink switches. Figure 39 shows the firing set with the covers removed, revealing the exclusion regions defined as follows:

Region 1 — Exclusion Region 1 of the firing set is protected by the bomb case and the LAC. All firing set components not isolated from external electrical signals by a stronglink switch are in Region 1.

[redacted]

Region 2 — This exclusion region is completely within the firing set container. It is isolated by the insulative barrier walls of the container and stronglink switches. The region contains the firing set power amplifier circuits and the MC2935 Trajectory Stronglink Switches.

Region 3 — This region contains the safety-critical fire set CDU circuits and weapon detonator cable assemblies. The firing set CDU circuits are isolated from unintended electrical signals by the firing set container walls and the MC2935 Trajectory Stronglink Switch in series with the MC2969 Intent Stronglink Switch. The firing set covers the detonator cables and protects them from inadvertent electrical energy.

[redacted]

The physical layout of the MC2918 Firing Set is configured to provide colocation of weak-link/stronglink elements. Ideally, the packaging would assure that the stronglinks are provided greater protection from severe environments than the weak-links. However, this ideal is seldom attainable within the constraints of volume, form-factor, and adjacent assemblies. The alternative is to control the location and/or destruct paths so that it is assured that the weak-links' destructive environmental level is reached prior to the time that the stronglinks' bypass environmental level is reached. For example, in some fire environments, heat may be directed at a side of the weapon that would tend to heat the MC2935 Stronglink Switch faster than the firing set CDU capacitor, and the MC2935 Stronglink Switch temperature may be greater than the capacitor temperature; however, the capacitor will become irreversibly inoperable while the MC2935 is maintaining isolation. This type of sequential response is necessary to assure a predictable, safe system response during abnormal environments.

As shown in Figure 39, the sealed covers of Region 1 of the firing set are not on the same surface as the covers for Regions 2 and 3. This allows hot and possibly conductive gases generated in Region 1 by an abnormal environment to escape without compromising the barriers between Region 1 and Regions 2 or 3.

DOE b(3)

The firing set housing and detonator cable cover is fabricated from fiberglass-reinforced, compression-molded MXB-71. MXB-71 is fire-resistant with excellent dielectric strength properties for temperatures up to 500°C. The openings in the barriers for the functional stronglink switch contacts and necessary openings into Regions 2 and 3 for test or reset of the MC2935s are sealed with high-temperature silicone. The metal mounting screws for the stronglink switches are through the container wall and are similarly closed from the exterior of the firing set by plugs of MXB-71 sealed with the same silicone.

To assure protection of the firing set exclusion regions by the stronglink switches, the contact assembly of each switch is constructed of metal and ceramic parts. The free volume is minimized to avoid bridging between input and output contacts by unintended conductive paths during abnormal thermal and crush environments. The switch housings are made of high-strength stainless steel to resist deformation in crush environments. The MC2969 and MC2935 can each withstand at least 1600 V dc at temperatures up to 400°C. Both switches contain discriminator mechanisms that, upon receiving an incorrect input signal, lock the switch in the open position. The MC2969 is resettable, requiring a pulse of correct length and amplitude to return the discriminator mechanism to its initial state. To be reset, the MC2935 requires both a manual release and a specific electrical signal input. Because physical access to the firing set is required, this procedure can only be done at a DOE manufacturing facility.

MC Requirements

Normal Environments

The B61-6,8 military characteristics state:

"The probability (per bomb lifetime) of a premature nuclear detonation for the normal environments described in the STS shall not exceed:

1. Prior to prearm (which includes application of the arming power and the unique intent enabling stimulus) and prior to release from the aircraft and in the absence of the trajectory stimulus, 1×10^{-9}.
2. After prearm and prior to release from the aircraft, and in the absence of trajectory stimulus, 1×10^{-6}.
3. After prearm and after release from the aircraft, and in the absence of the trajectory stimulus, 1×10^{-3}.

The probability (per occurrence) of a nuclear detonation in the normal release envelope after receipt of the trajectory stimulus shall not exceed:

1. Prior to expiration of the safe separation time, 1×10^{-3}.
2. After expiration of the safe separation time and prior to the intended detonation, 1×10^{-2}."

Abnormal Environments

The military characteristics for the B61-6,8 state:

"The probability (per occurrence) of a nuclear detonation of a bomb for individual or credible combinations of abnormal environments specified in the STS shall not exceed:

1. In the absence of any unique intent and trajectory stimuli, 1×10^{-6}.
2. After receipt of the unique intent and in the absence of the trajectory stimulus, 1×10^{-3}.
3. Placing the normal/override switch in the override position shall be considered intent enabling stimulus."

Safety Subsystems

Fault tree analysis techniques are useful for defining and evaluating the nuclear safety design of the bomb system. Figures 40 through 43 are abbreviated examples of fault trees. These figures illustrate the three safety subsystems incorporated in the B61-6,8 to meet nuclear detonation safety requirements in normal and abnormal environments. Both DOE (Sandia, Los Alamos, and production agencies) and DoD requirements are addressed.

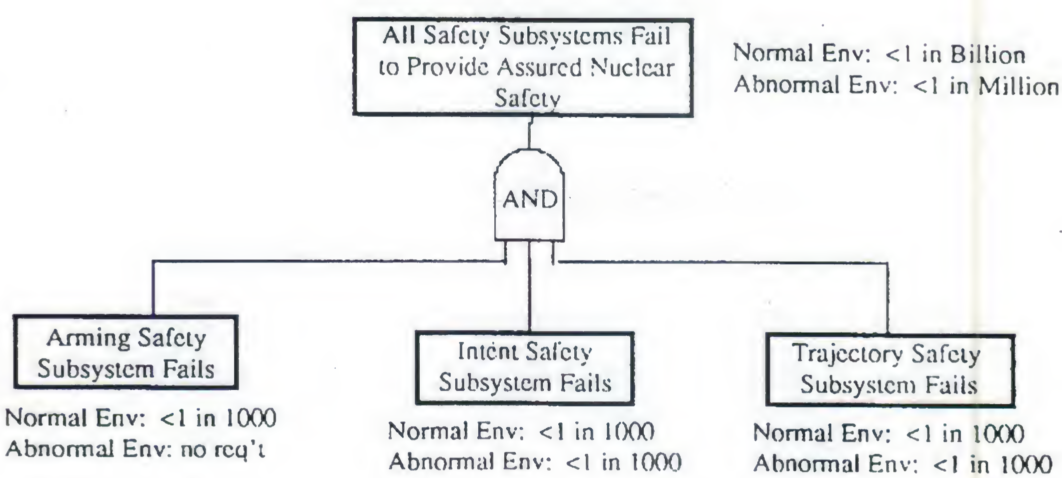

Figure 40. Fault Tree, Loss of Electrical System Safety

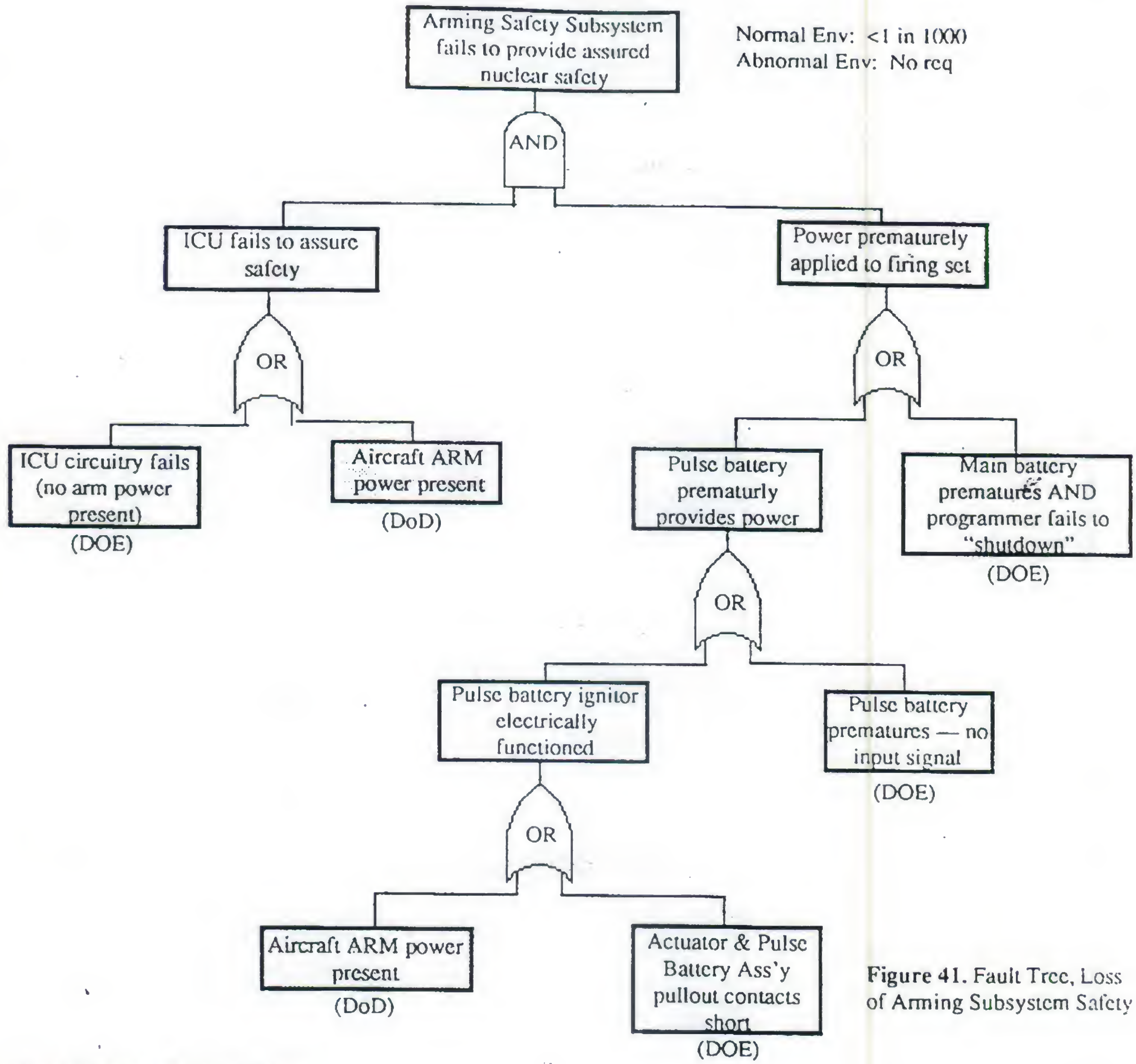

Figure 41. Fault Tree, Loss of Arming Subsystem Safety

Arming Safety Subsystem

The arming subsystem, when combined with the intent and trajectory subsystems, provides the additional 1×10^{-3} nuclear detonation safety to achieve the MC requirements in normal environments. No abnormal-environment nuclear detonation safety requirements are placed on this subsystem. This subsystem prevents the application of normal environment aircraft and bomb electrical system signals to critical circuits. Electrical signals at the bomb umbilical and preflight controller connectors are restricted to prescribed PAL or stronglink monitor signals from the aircraft or T-gear.

The component assemblies included in the arming subsystem are the MC2213(A) Actuator and Pulse Battery Assembly, the MC2238A/B Pulse Batteries, the MC3656 Main Batteries, MC4138 Programmer, and the MC4140 ICU. The delivery option selection circuitry and the ICU software provide positive control of the output of the pulse batteries. Premature actuation of a pulse battery will result in system "shutdown" without the required aircraft delivery option voltage being present. Premature of the main battery will similarly result in system "shutdown" by the programmer. Both premature actuation of the pulse battery and aircraft prearm power must occur for the ICU and programmer to function in the intended use mode. For the arming safety subsystem, the DoD must insure that prearm de-power is not applied to the umbilical connector. The DOE will insure the components involved meet the design requirements.

Intent Safety Subsystem

As shown in figure 42, both the DoD and DOE must meet requirements for the Intent Safety Subsystem to provide assured nuclear detonation safety. The DOE must assure that the MC2969 ISLS in the firing set meets the isolation requirements and is only enabled upon the application of the IUQS. The DoD must assure that the IUQS signal is not generated prematurely due either to inadvertent or inappropriate human action or hardware malfunction of the IUQS generator in the AMAC. Both DOE and DoD must meet these requirements in the event of an abnormal environment.

If the MC3025 Signal Selector is in the OVERRIDE position, there are no requirements of the intent safety subsystem to provide protection in an abnormal environment. With the selector in OVERRIDE, the bomb will meet only a 1 x 10^{-3} probability of a nuclear detonation in an abnormal environment. Additionally, 1 x 10^{-3} probability of a nuclear detonation can only be met in the "absence of the trajectory stimulus."

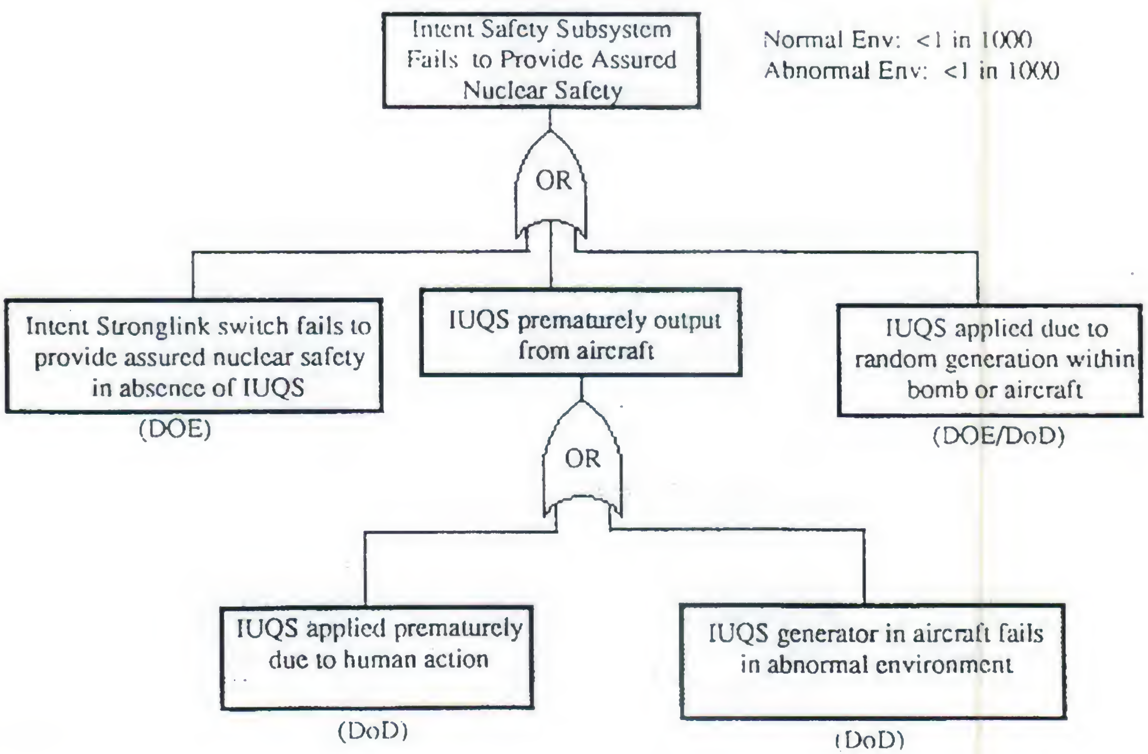

Figure 42. Fault Tree, Loss of Intent Subsystem Safety

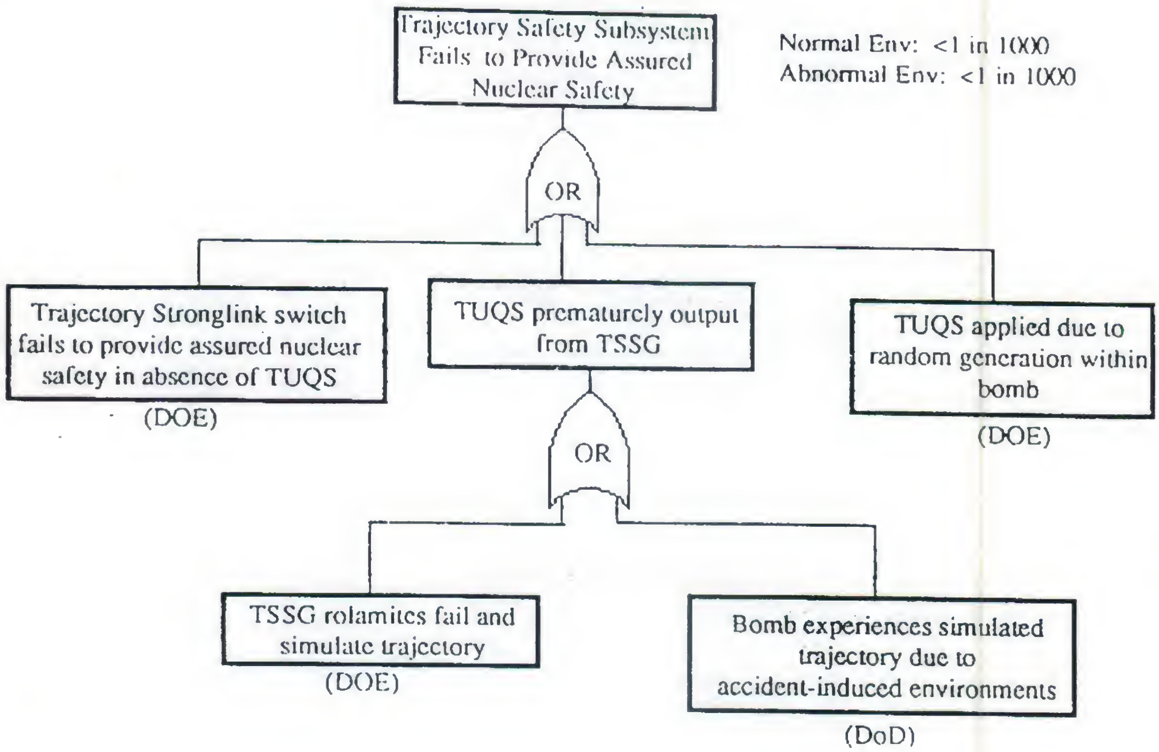

Figure 43. Fault Tree, Loss of Trajectory Subsystem Safety

Trajectory Safety Subsystem

Of the three nuclear safety subsystems, arming, intent, and trajectory, only the trajectory safety subsystem is composed entirely of DOE hardware. The DoD responsibility is to assure that no accidental simulation of the "intended use" environment (retardation or spin) occurs. Major components within this safety subsystem are the MC4175 TSSG or the MC4137 TSSG and the MC2935 Trajectory Strong-Link Switch in the firing set. The MC4175 TSSG is identical to the MC3640 TSSG (B61-7) except for a connector change and will support B61-6 production for the first six months until the MC4137 TSSG is available.

MC4175

The MC4175 TSSG is a second-generation design of trajectory sensing devices incorporated into B61 bombs to enable (close) the MC2935. In the mid-70's, the MC2948 TSSG was designed for first use in the B61-5 and was later used on the B61-3,4. Both the MC2948 TSSG and MC4175 TSSG use "stronglink/weak-link" design philosophy to achieve nuclear safety in abnormal environments. The normally open, acceleration-sensing rolamite switches (stronglinks) interrupt electrical power from the TSSG electronics that generate the trajectory unique signal (TUQS). The application of power through the inertial rolamite switches to the electronics will produce the TUQS to drive the MC2935. Thus the design theme requires that the TSSG rolamite switches (stronglinks) be capable of surviving, without shorting, higher levels of shock or temperatures produced by an accident environment than the TUQS-producing electronics/ceramic circuit board (weak-link). Failure of the stronglinks in severe environments is acceptable, but only if the weak-link also fails irreversibly.

Figure 44 is a simplified block diagram of the trajectory safety subsystem with the MC4175 TSSG which illustrates the electrical connection for both the parachute retarded and spin-stabilized freefall delivery modes of the bomb. Functional contacts of the MC2969 Intent Strong-Link Switch are required to be closed before the TUQS can drive the MC2935. Both the intent and trajectory safety subsystems are designed to meet a goal of 10^{-3} given an abnormal environment; each is considered to be independent and no contribution to the trajectory safety subsystem because of the interruption of the MC2935 drive lines by the MC2969 is assumed. In the spin-stabilized bomb delivery mode, one radially oriented rolamite switch in each of the two TSSGs must close before the series circuit is closed between the bomb power source and the TUQS-producing electronics. The two MC4175 TSSGs are mounted opposed to each other equidistance from the

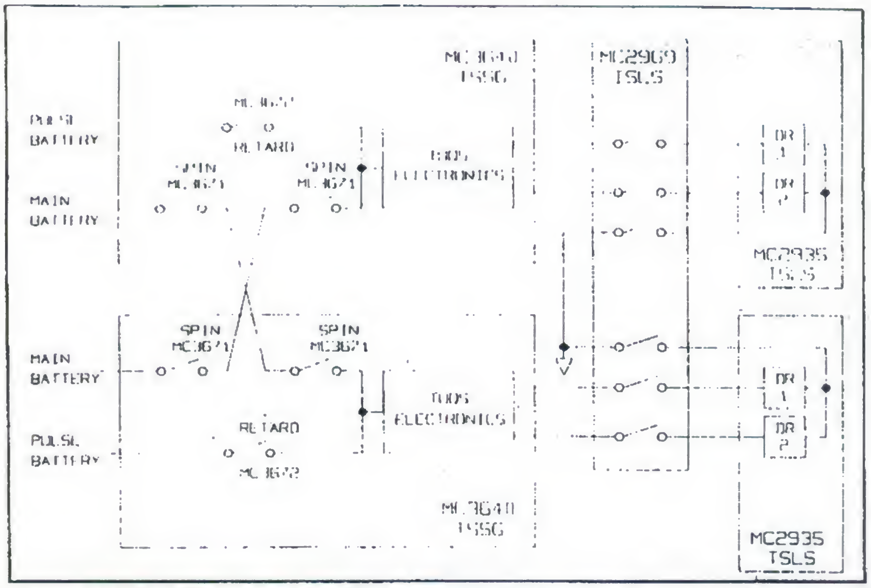

Figure 44. Block Diagram, Trajectory Safety Subsystem with MC4175 TSSG

bomb's longitudinal center line so that a radial acceleration or deceleration may cause both of the radially-mounted rolamites in one TSSG to close, but the spin rolamites in the opposite TSSG will remain reset. Spinning of the bomb is required to close all four spin rolamites.

Numerous shock tests of the MC3671 (spin) and the MC3672 (retard) rolamites have revealed the MC3671 to be most susceptible to shock: 4000g, 1ms when the direction of the shock causes the rollers to travel from the reset end (resting end) to the actuate end. The heavier rollers of the MC3671 travel to the actuate end with sufficient velocity/energy to separate the end cap from the case. In all other directions the MC3671 is 6000g's or greater, as is the MC3672 in all directions, including the actuate direction.

By design, the ceramic printed wiring board for the TUQS electronics is the weak-link for the MC4175 TSSG in the shock environment. The two-sided bonding of the DAP rolamites to the mica housing of the MC4175 TSSG insures minimum failure levels of approximately 6000g's. Whereas shocks perpendicular to the ceramic board result in breakage at as low as 330g, shocks in the plane of the board do not result in predictable failures (fracture). Abnormal environment testing of the ceramic boards have shown boards to survive ~7000g's in the plane of the board (undesirable since the stronglink rolamites can fail at lower levels). However in no system test nor component-level testing of complete MC3640 TSSGs for the B61-7 did there exist an "unsafe" condition. Some abnormal environment tests have resulted in damaged rolamites and/or lack of adhesion to the exclusion region barrier and an undamaged circuit board, but none exhibited a short circuit that could transmit power to the electronics. With the actuate contacts on one end of the rolamite, bypass requires the band or roller to remain at the actuate end. None of the damaged rolamites exhibited a potential for that condition.

Two polycarbonate capacitors, essential components for the generation of the TUQS, are used as the thermal weak-link. Both the DAP rolamite and the glass-bonded mica housing of the MC4175 TSSG retain excellent electrical insulative properties to the structural limit of the materials in high thermal environments. With a repeatable and irreversible failure temperature of 350° to 400°F, the polycarbonate capacitors will fail long before bypass of the rolamites or the housing is possible.

It is important to note that "trajectory sensing" implies the parachute was deployed and the resultant retardation forces were sufficient to close the rolamite switch or the bomb spin rate is adequate to close similar, radially oriented rolamite switches. No discrimination capability between an "intended use" and a "trajectory" resulting from an accident is possible. Any airborne accident can result in damage to the bomb tail section and resultant parachute deployment or adequate spin rates developing due to the bomb fin cant necessary to maintain roll rate for accuracy in freefall deliveries.

MC4137 TSSG

Where the MC4175 depends solely on the stronglink/weak-link design philosophy, the MC4137 also incorporates "intent-enablement" as a safety enhancement. The "intent-enabled" design of the MC4137 requires the MC4137 TSSG electronics to "store" the IUQS signal which enables the MC2969 Intent Strong Link Switch in the firing set during the prearming of the bomb before aircraft release. The TUQS signal is not "stored" in the MC4137 electronics. Without the information content of the IUQS signal, the MC4137 cannot formulate the TUQS signal. The strong link/weak-link packaging of the TSSG is also retained since the "intent-enablement" is a nuclear safety "enhancement." The trajectory safety subsystem is required to provide 1×10^{-3} protection in abnormal and normal environments requiring independence of the three safety subsystems. The strong link/weak-link packaging of the TSSG will be addressed during development as rigorously as would be required if the TUQS were "stored."

To improve the packaging for abnormal environments, both channels of the MC4137 are packaged in a single steel/aluminum enclosure (Figures 18 and 45). Conductive housing and barriers of steel are used to maintain mechanical integrity in abnormal environments. The steel housing, exclusion region barriers, and rolamites are electrically conductive and designed to divert unintended, accident-induced energy to ground. Isolation of all signals from the case is required in normal environments for reliability.

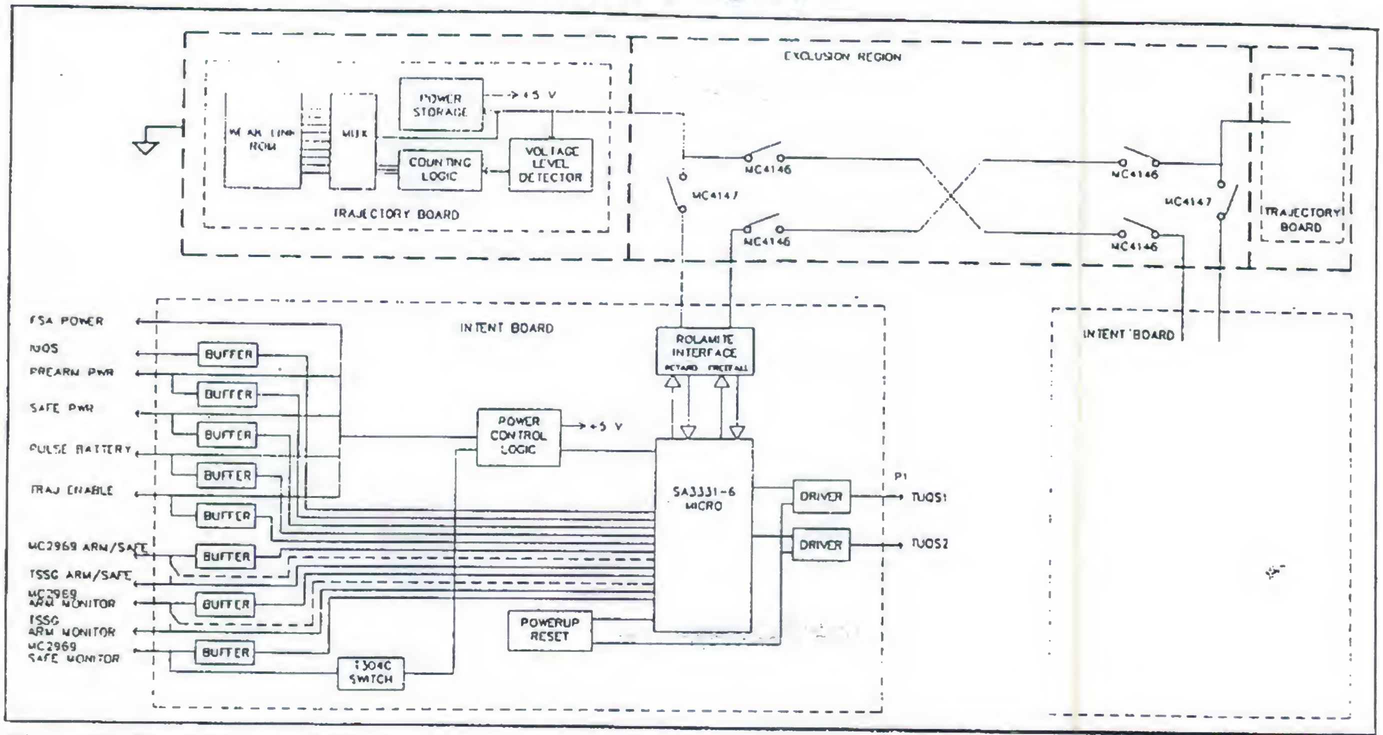

Figure 45. Block Diagram, Trajectory Safety Subsystem with MC4137 TSSG

Both of the new rolamites in development (MC4146 to sense bomb spin and MC4147 for retarded drops) are steel-case, hermetically sealed assemblies. As in the MC4175, there are two spin rolamites per channel connected in series, diametrically opposed in the bomb to require true spin of the bomb. Previous rolamite designs have been constructed of insulative materials with the conductive band as the signal (power) path between the actuate contacts. The new rolamites are designed for increased ruggedness and predictability in abnormal high shock environments. The steel rolamites and TSSG housing (exclusion region barrier) will each incorporate mechanical mounting features that will insure integrity of the rolamite/barrier union through all abnormal environments. This design will result in the rolamite case electrically grounded to the housing (system ground). Therefore the contact block in the roller is required to be isolated from the roller and the band. The required electrical path is through the pins and the contact block (see Chapter 2).

In the block diagram (Figure 45) shown above, the exclusion region encompasses the rolamites, weak-link ROM, and circuitry necessary to interface with the SA3331-6 microprocessor. Each "intent board" is packaged outside the exclusion region and contains the aircraft interface circuitry, microprocessor, and TUQS drive circuits. To format the TUQS signal, each independent channel of the MC4137 TSSG (an intent board and a trajectory board plus three rolamites) will combine the information from the IUQS signal stored in the microprocessor with 24 bits stored in a thermal weak-link ROM (read only memory). Low melt alloy loops on a printed circuit board (Figure 18) form the 24 bits of the weak-link ROM. Melting of the "loops" in high temperatures from abnormal environments will result in either opening or shorting to the board. Either alternative is "safe"; combining with the IUQS signal would lock up the MC2935 TSLS. Early thermal testing of the TSSG has recently led to redesign of the housing and weak-link ROM to mount the ROM to the outer wall of housing. An instrumented unit with representative rolamites and housing indicated the weak-link ROM would reach guaranteed failure temperature as the rolamite temperature was approaching its design temperature limit of 500°F, with the ROM mounted on the ceramic board. Mounting of the ROM near the outer TSSG wall resulted in considerable margin.

An additional nuclear safety enhancement achieved in the design of the MC4137 TSSG is the use of "volatile" memory (without power the IUQS code will be lost) to store the IUQS code during the prearm of the bomb. A permanent memory ("non-volatile") would require certification of the erasure of the IUQS after in-process, acceptance, and system level testing. On a "first principles" basis, the incorporation of the "volatile" memory is most attractive and defensible from a nuclear detonation safety standpoint. Capacitive "hold up" energy storage in the MC4137 will assure that the IUQS is retained for a minimum of 7 seconds in the event of an intermittent aircraft power dropout. If all arming power and monitor power is lost for longer than 7 seconds minimum

(~2 minutes maximum), the MC4137 will interrupt the arm monitor line to the AMAC. On Navy System 1 aircraft (A-7E and F/A-18), this will result in both the "arm" light and the "safe" light being illuminated when power returns. On the FSA aircraft, the "disagreement" light will illuminate when power returns. The reapplication of arm power in this situation will cause the MC4137 to erase the IUQS memory locations thereby ensuring a "safe" state. A power dropout long enough to cause this condition will require the pilot to retransmit the IUQS and again "arm" the TSSG. Power dropouts of shorter duration will not affect the AMAC indications until after the MC2213 capacitive network has discharged (or cause additional pilot workload). The use of "volatile" memory for IUQS retention is a desirable nuclear safety design feature.

Although the B61-6,8 MCs only require compatibility with Navy strike aircraft, the MC4137 TSSG will be designed to be compatible with all aircraft approved for carriage of any B61. Since some aircraft (e.g., B-1B and B-52 CSRL) interrupt prearm power after sending the IUQS for undefined, extensive time intervals, the MC4137 will use "safe monitor" power to hold up the "volatile" memory. Only microamperes of current is necessary for hold up and all required bomb impedances are maintained. Additionally, all aircraft listed in the B90 MCs will be tested for compatibility during development for future application of the MC4137.

After release from the aircraft and rise of the bomb pulse batteries, the MC4137 will use the closed rolamite contacts (either the single retard or the two spin rolamites) to obtain the pattern stored in the weak-link ROM. One-by-one each of the 24 ROM bits is obtained and "exclusive-OR'ed" with the corresponding bit of IUQS and transmitted to the MC2935 TSLS in the firing set. Each bit is obtained from the ROM consistent with the TUQS pulse constraints. Premature closure or opening of the rolamites will indicate an abnormal, or accident environment and result in transmittal of an incorrect TUQS code and locking up the MC2935 TSLS.

Analyses and Tests

The "individual or credible combinations" of abnormal environments to which the B61-6,8 may be subjected throughout the STS are: impact, crushing, puncture, thermal, unintended electrical sources, lightning, and chemical immersion. The bomb is designed to have a safe response in these abnormal environments, even in the presence of activated battery power sources within the bomb. Similarly, electrical signals (except the unique signals) from external sources can be applied anywhere outside the exclusion region and the bomb will meet the premature requirement. Analyses and/or tests will be performed on the B61-6,8 where necessary to confirm the design theme to each of the general classifications of abnormal environments. Much of the abnormal environment testing on the B61-3,4 is applicable to this program, and a major reduction in the number of fullscale tests necessary to confirm the nuclear safety design of the B61-6,8 was achieved. The following is a summary of the bomb response in each type of abnormal environment.

Individual Abnormal Environments

Impact

Abnormal impact environments can be produced through aircraft or truck crashes and accidental dropping of the weapon. Maximum aircraft impact velocities of over 1500 fps or mid-air collisions resulting in the bomb freefalling to earth at velocities of up to 1600 fps are possible.

Design Theme. We require the stronglink/exclusion region to remain intact and the stronglinks to remain in the reset (open) position until the HE-nuclear system (weak-link for this environment) is nonfunctional.

DOE b(3)

DOE/DOD b(3)

[redacted]

One B61-6,8 system test is being planned. A nose-on impact test at a velocity (to be determined) greater than the last B61-7 test (328 fps) and less than 492 fps will be conducted to confirm the extrapolations made on the B61-7 test. This test unit may also be used to investigate the effect of combined abnormal environments (thermal followed by impact).

Of the new components in development to support the B61-6,8, only the MC4137 TSSG has abnormal environment requirements. The weak-link ROM will be characterized in shock on both component-level testing and system tests where appropriate.

Crushing

This environment is a semi-static situation where, for example, during an accident a structural member of the aircraft comes to rest on the weapon case.

Design Theme. The MC2969 and MC2935 stronglink switches are required to hold off any energy reaching the fire set in this environment. With the structural properties of the thick aluminum center case and the steel support sleeve serving to protect the exclusion region from direct exposure to the outside world in any credible static crush abnormal environment, no weak-link needs to be identified.

Response Analysis/Tests. Tests conducted on the B61-5 and the B61-3,4, each with the identical center case (but with different support sleeve designs), showed almost linear deformation with applied load until case rupture at 305,000 lbs and 335,000 lbs, respectively. In each test, loading was applied through a rigid 2-inch bar placed perpendicular to the longitudinal axis of the bomb over the firing set. In accident possibilities for the B61-6,8, the forces necessary to rupture the center case do not exist. For example, a fully loaded B-52 weighing about 500,000 lbs could rest at most one-half or 250,000 lbs on a B61-6,8. Maintaining the integrity of the center case, with the stronglinks ensuring electrical isolation to the practical limit of the environment, assures meeting the 1 in 10^6 safety requirement.

Thermal

Complete or partial bomb engulfment by a JP-series kerosene (jet fuel) fire is possible. Fuel supplies are assumed to be sufficient to allow all processes to run to completion.

Design Theme. In abnormal thermal environments, predictable nuclear safety is accomplished by stronglink/weak-link colocation within an exclusion region whose barriers primarily consist of a high-temperature insulation material, MXB-71, and ceramic dielectric in the stronglink switches. The applicable weak-links are the X-unit capacitor and the nuclear system high explosive and detonators.

Response Analysis/Tests. Tests demonstrating safe response in abnormal thermal environments conducted during the B61-3,4 program included the following:

- High-temperature tests on switches and barriers up to 1000°F
- High-temperature tests on weak-links (capacitors and IHE) to determine failure threshold
- High-temperature tests on 12 firing sets at temperatures up to 1850°F
- High-temperature tests on four B61-3,4 test units.

The mechanical packaging and therefore the thermal properties of the B61-6,8 is identical to that of the B61-7. [redacted] The test unit was configured to provide exposure of a 120° arc of the center case directly to the fire with the remaining portion of the bomb exterior insulated and protected from direct flames. In this way, the most preferential heat path to the stronglink switches is obtained and therefore a worst-case test results. The thermocouple data (Figure 46) indicated the desired close thermal-tracking of the stronglink and weak-link temperatures. Thermocouples within the IHE indicated that in this orientation the IHE starts burning before the X-unit capacitor reaches failure temperature. The bomb IHE was totally consumed in the fire without detonating. Posttest examination of the firing set revealed total thermal destruction of the mylar X-unit capacitor while the stronglinks retained voltage

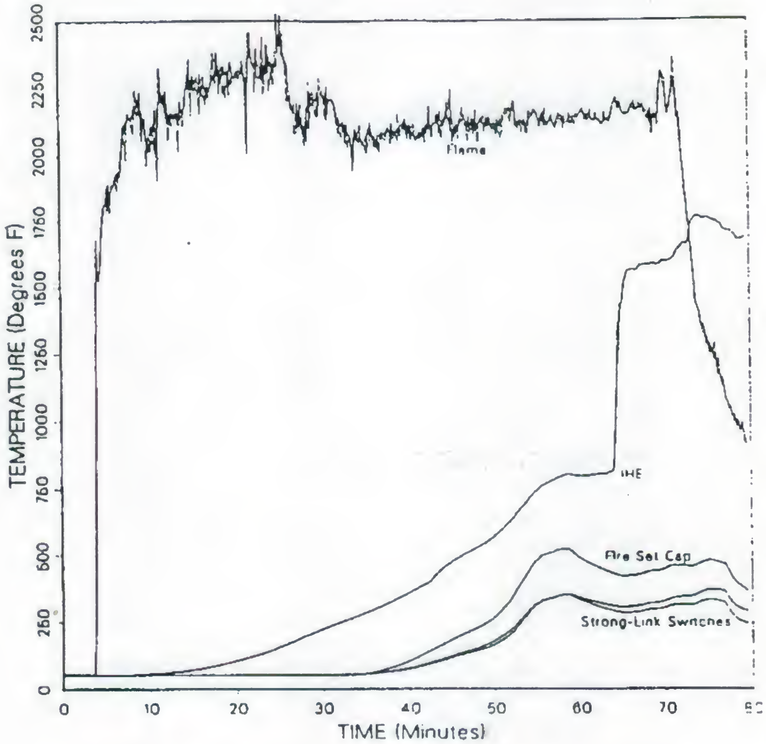

Figure 46. Thermocouple Data From B61-6,8 Fire Test

standoff capabilities to requirement levels.

Because of the applicability of the B61-7 test described, no bomb-level thermal verification test of the B61-6,8 is planned. Thermal testing of the MC4137 TSSG will be performed to verify the response of the weak-link ROM and establish the adequacy of the 500°F limit on the new steel rolamites.

Puncture

Puncture of the bomb by projectiles/fragments could create conductive paths that do not exist in normal environments.

Design Theme. The stronglink switches are located in the inner region of the bomb cross-section. Surrounding components and materials afford physical protection of the switches and exclusion region barriers. [redacted] The use of multiple arming signals further assures predictable nuclear detonation safety in this environment.

b(3) DOE

Response Analysis. High-kinetic energy fragments can penetrate the bomb center case, the steel sleeve, and the firing set housing. If the fragments damage the weak-links to such an extent that the nuclear system is rendered inoperable, nuclear safety is assured, regardless of bypass paths. If the fragments merely leave holes in the case, no arming occurs. If the fragments cause conductive paths into the exclusion regions, it would be expected that these paths would be shorted to either or both the conductive center case or the conductive inner case and thus shunted away from critical arming circuits. In order to constitute a threat, a series of unlikely conditions must occur: the fragment must provide continuous conductive paths from power sources to critical circuits within exclusion Region 3; the paths must be insulated from the center case and steel sleeve that the fragment penetrated; and during the penetration, the fragment must not destroy the weak-links (X-unit capacitor, detonators, or IHE). It is believed these simultaneous occurrences are not credible.

Unintended Electrical Sources

In all abnormal environments, the presence of electrical power is assumed to be present. Electrical power on the drive lines to the stronglink switches would threaten the nuclear safety design if the stronglinks could be enabled (closed) by "ordinary" electrical signals.

Design Theme. Inadvertent electrical signals are prevented from arming the warhead through isolation provided by the exclusion region barriers and stronglink switches that respond only to a unique pattern of signals.

Response Analysis. The necessary information content of the unique signal pattern discriminated by both the MC2969 Intent Stronglink Switch and the MC2935 Trajectory Stronglink Switch were selected to obtain a suitably small probability of inadvertent generation of the unique signal patterns by extraneous signal sources.

The probability of a random signal format driving the MC2969 or MC2935 to a closed position has been calculated. Safety-conservative assumptions are that an extraneous signal source produces only pulses of the required format (i.e., amplitude and pulse width), in the proper ratio of events, that are pairwise dependent, and are applied to the proper lines. The MC2935 is a single-try switch with a unique signal pattern of 20 pulses on two lines while the MC2969 is a multiple-try device with one drive line requiring a specific pattern of 47 long and short pulses. Calculations show the probability of enabling the MC2935 is about 1 in 10^6 as compared to the requirement of 1 in 10^3. The probability of unlocking the MC2969 is 6.0×10^{-9} on the first try while all subsequent trials are 1.6×10^{-10}. Over a year of trials (millions) can be tolerated and still meet the 10^{-3} probability requirement.

Lightning

Design Theme. Lightning protection for the B61-6,8 is provided by enclosing safety-critical firing set and detonator circuits within a conductive center case and cover. The only points of entry into the center case are through a LAC in the cover plate and the radar cable from the nose. The radar cable entering the center case is protected by the conductive radar housing.

Response Analysis. The LAC is designed to function as a normal connector for operational signals but provide a preferential breakdown path to the center case for lightning energy present at the case entry point. The LAC will limit the voltage within the center case to a maximum of 1400 V, while the stronglink switches and exclusion region barriers maintain safety-critical isolation of at least 1600 V at 400°C and 2600 V or higher at temperatures of -55°C to +75°C. Safety in the lightning environment depends primarily on assuring that the LAC breakdown characteristics are controlled so that all LACs breakdown to the case before the voltage holdoff capability of the stronglink switches is exceeded. Each and every pin of every LAC is tested to confirm that the breakdown voltage criterion is met. Sample units from each lot of stronglink switches are destructively tested to assure that the lot conforms to abnormal environment requirements, including breakdown voltage at room and elevated temperatures. Reference 31 concludes that the 1×10^{-6} probability is met even if units rejected by the screens are included in the population.

Chemical/Immersion

Response Analysis. Because the center case is conductive, it is not credible to assume that electrical energy could be applied to the electrical system in the presence of a conductive fluid which could bypass the stronglink switches and simultaneously maintain isolation from the bomb case (electrical ground).

Combined Abnormal Environments

The B61-6,8 MCs require nuclear detonation safety be achieved "for individual or credible combinations of abnormal environments specified in the STS." The applicable STS for the B61-6,8 has been distributed for comments and revision. The section defining credible combined abnormal environments is being discussed and a revision has been proposed. Therefore the specific STS guidance to which the design and evaluation program for the B61-6,8 will be judged is not available.

The bombs response to combinations of abnormal environments relies on the demonstrated safe response to individual abnormal environments by virtue of the stronglink/weak-link/exclusion region design concept. For all single abnormal environments identified in the STS, it has, or will be shown that either the weak-link elements of the nuclear system or firing set become irreversibly inoperable prior to the stronglink failure, or the stronglinks maintain electrical isolation. Additionally, the relative stronglink/weak-link failure levels are sufficiently separated so that an abnormal environment not severe enough to disable the weak-link is below the level necessary to degrade the stronglink/exclusion region isolation. Thus, there are two predictably safe responses to an abnormal environment that have a direct bearing on system response to sequential exposure to abnormal environments:

1. The weak-link has become irreversibly inoperable prior to stronglink failure or bypass.
2. The stronglinks remain intact (the weak-link has not failed).

Given response #1, bomb exposure to subsequent abnormal environments would not result in a nuclear detonation since the system was rendered inoperable by the initial exposure.

Given response #2, the bomb is expected to withstand additional abnormal environments terminating in a safe condition with either the stronglinks intact or with the weak-link inoperable prior to stronglink failure or bypass.

There has never been a entire bomb system exposed to an ordered sequence of abnormal environments. There has been abnormal environment testing performed at the major component level (e.g., the firing set) to identify potential problem areas. Numerous tests have been performed on the MC2918 Firing Set to establish structural properties and dielectric properties of the stronglink/exclusion region following a high thermal abnormal environment. There are development activities in progress to improve the structural support of the stronglink switches following elevated temperatures resulting from fire and therefore address a combined abnormal environment of high thermal followed by shock. An aircraft crash (shock, static loading of the case) followed by fire is a "more credible" order of the combined environments and one for which the firing set response is predictably safe.

There are plans to test the new MC4137 TSSG to combined shock and thermal tests. The steel case (exclusion region) and rolamites were selected based on the threat of combined abnormal environments. The sequence of the thermal and shock should pose no threat to the predictability of the all-steel design.

5. Reliability

Summary

The reliability of the B61-6,8 has been predicted using the methods briefly described in this chapter. [redacted] To predict the bomb reliability, a failure analysis is performed for each component. Current assessments are used for the components of the parent weapon or those that are common to the B61-7 or B61-3,4 based upon stockpile data. Predictions for new components are based on all available data from similar components in comparable weapon systems and on data for individual piece parts and their design use.

The command disablement system is to have the following MC-specified reliability and premature probability characteristics:

[redacted]

Delimiting Conditions

The predicted reliability is conditional on the following:

1. Stockpile and use environments will be no more severe than the normal logistical and operational environments described in the STS.

2. All AMAC inputs will be present and proper.

3. There will be no human errors in bomb handling or preparation for use that will reduce its reliability.

4. The bomb and all of its components will be built to the usual DOE standard of production and process control.

5. The specified end-of-life of limited-life components will not be exceeded. Reliability assessments are considered to apply at the end of specified-life for limited-life components.

6. Failure events not treated otherwise are mutually exclusive or statistically independent.

Conclusions

[redacted]

Intentionally Left Blank

6. Use Control

The B61-6,8 use control features include a command disable system and a Category D PAL System. Additional details about these features are discussed in the Use Control Addendum for the B61-6,8 Bomb (Reference 37).

Command Disable System

Command disablement of the B61-6,8 can be initiated from the aircraft or at the preflight controller (Figure 23) on the bomb. [redacted] The disablement system is composed of a DE1002 Coded Device and a MC3246A Thermal Battery.

Disablement results when (1) the correct three-digit disablement code is set on the DE1002 Code Switches, (2) the function select switch is set to the DI (disable) position, and (3) the T-handle is extracted, mechanically initiating the MC3246A battery. The disablement loads located within the bomb center case, each isolated by discreet resistors within the MC4139 Junction Box, are in parallel off the output of the MC3246A battery.

[redacted]

Category D PAL

The B61-6,8 Category D PAL subsystem consists of an MC2907A Multiple Code Coded Switch (MCCS), an MC2946 Output Switch, and a PAL Regulator. When the subsystem is locked, the bomb cannot be prearmed. The PAL subsystem is shown schematically in Figure 47.

MC2907A Multiple Code Coded Switch

[redacted]

DoD b(3)

DoE/DoD b(3)

[redacted]

MC2946 Output Switch

The MCCS utilizes the MC2946 Output Switch to provide positive control of selected bomb prearming signals. Whenever the MC2946 is unlocked, the PAL unlock monitor will be switched to system return. This monitor allows a PAL-capable AMAC or ground control equipment to verify that the PAL is, or is not, locked. The functional and monitor contacts are mechanically interlocked to ensure agreement of contact position.

PAL Operations

The lock/unlock/recode PAL operations can be performed on the B61-6,8 at the bomb/aircraft interface connector or through the PAL connector on the preflight controller.

Category D PAL Control Equipment

T304C Continuity Test Set

The T304C monitors the state of the MC2946 Output Switch (open/closed). It contains a manually-operated generator and therefore requires no additional power supply.

T436 and T436B Power Supplies

The T436 and T436B (Figure 48) are power supplies (28 V Ni-Cd batteries) that can be used with the T1535, T1536, T1539, T1555, or T1563 PAL Controllers.

T431A Charger Monitor

The T431A tester charges and monitors the T436B Power Supply.

CT1495 Adapter

This adapter is used with the CT1478 Cable to connect the T436 Power Supply to the T1535, T1536, T1539, T1555, or T1563 PAL Controllers.

T1528 Adapter

[redacted]

DoE DoD b(3)

T1535 Portable Decoder

The T1535[32] is a ground decoder for Category D and F PALs. It operates with a T436B Power Supply and it can lock

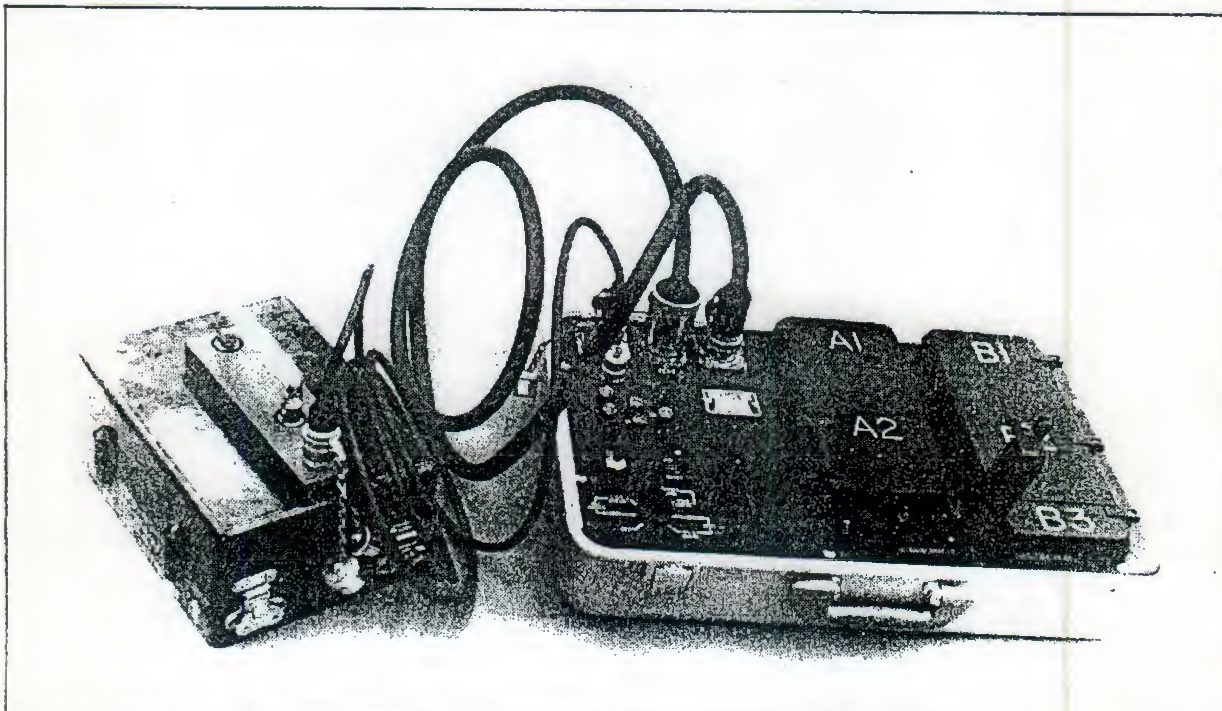

Figure 48. T436B Power Supply Connected to T1536

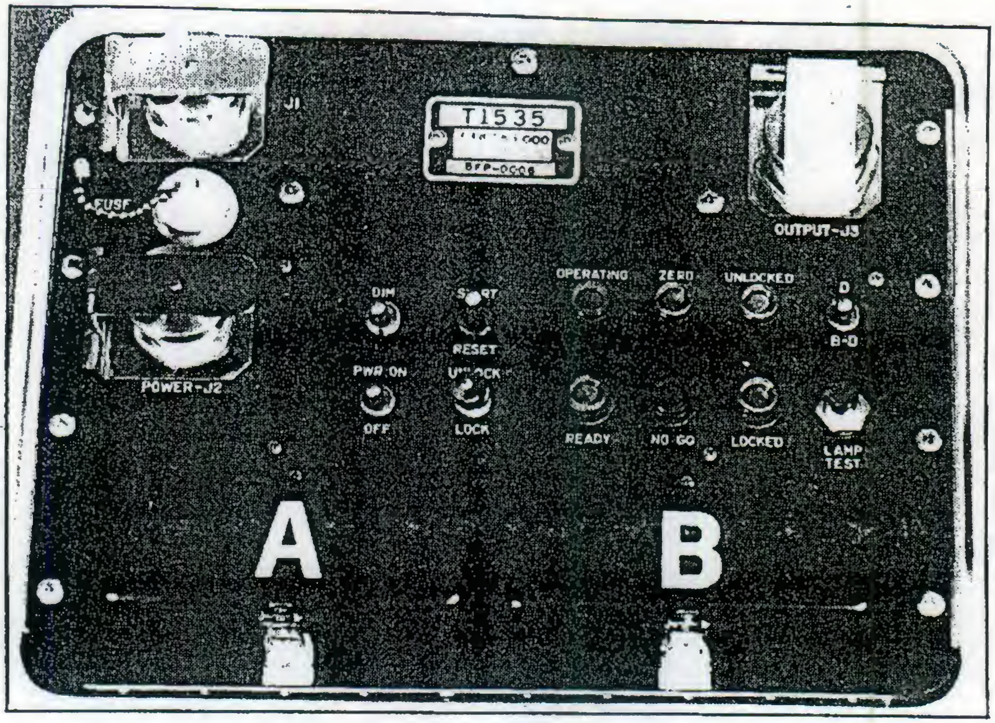

Figure 49. T1535 Portable Decoder

or unlock the B61-6,8 PAL. When the portable decoder is used for mixed and/or multiple loads, safe power must be provided to each weapon. In this operation, the T1535 can furnish sufficient input for several Category D weapons in parallel (Figure 49).

T1536 Portable Recoder

The T1536[33] is a ground recoder used to recode and code check the B61-6,8 (only one bomb at a time can be recoded). The controller can change one code at a time or all codes, and the PAL is always left locked after a recode operation. The codes can be checked without affecting the status of the PAL. The status of the limited try is also shown. The code dials are equipped with privacy covers for operation by a team with split knowledge of the code (Figure 50).

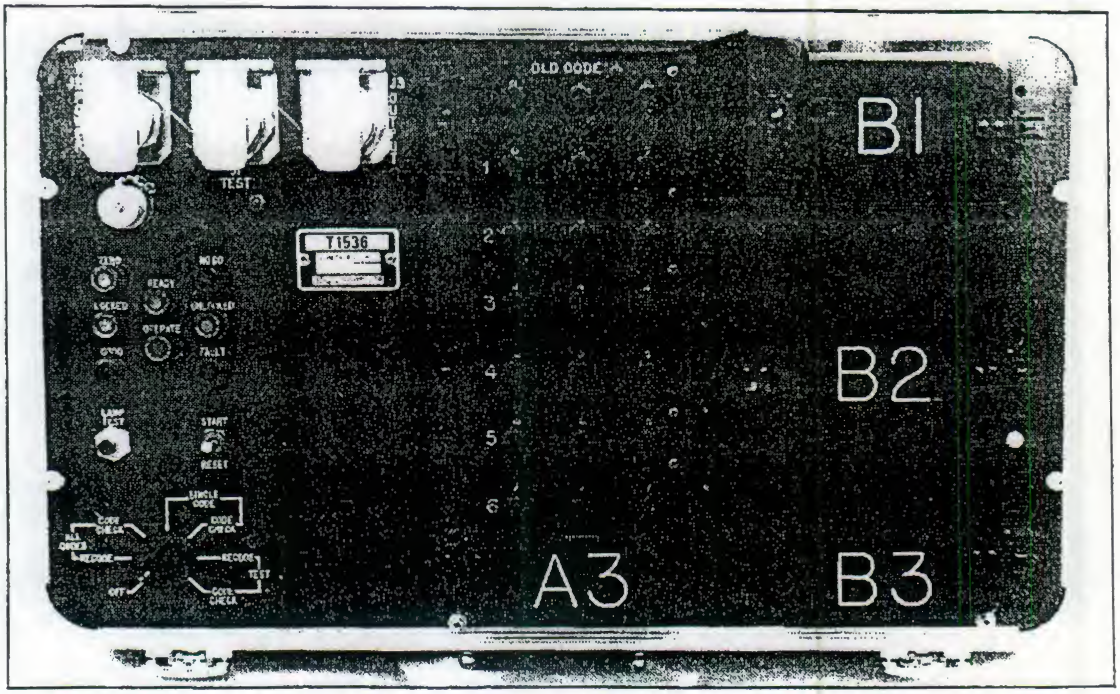

Figure 50. T1536 Portable Recoder

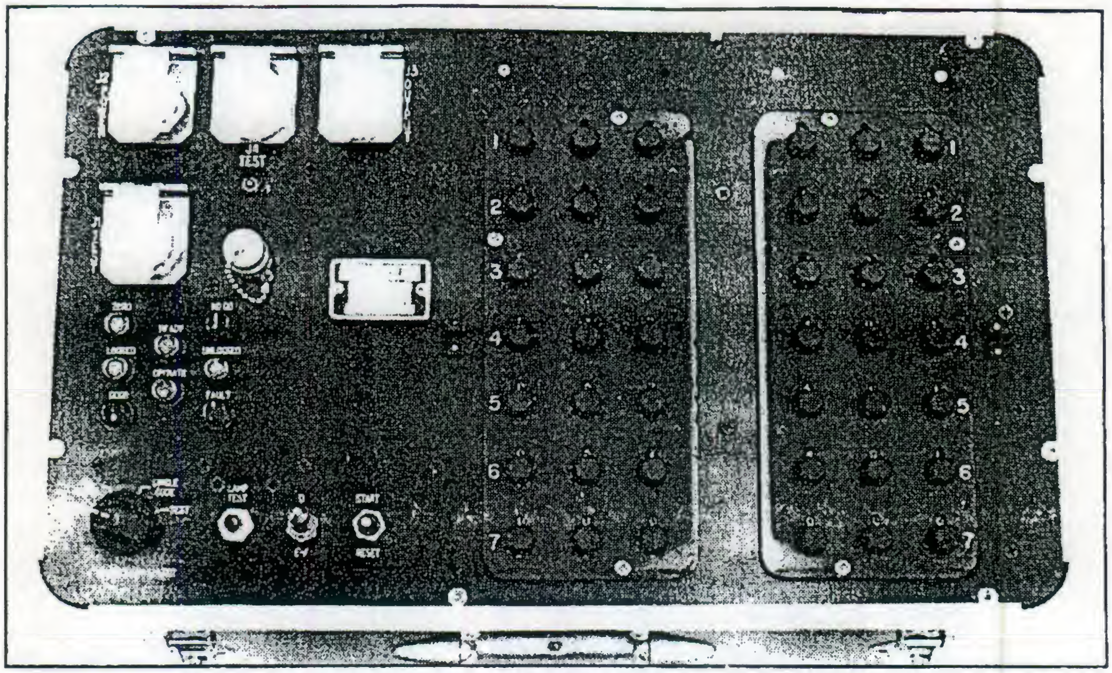

Figure 51. T1539 Code Verifier

T1539 Code Verifier

This verifier is used by a code verification team to check that the proper code(s) is (are) in each weapon. It does not have a lock, unlock, or recode capability. This verifier also has privacy covers for operation by a team with split knowledge of the code (Figure 51).

T1542 Adapter

[redacted]

T1549A Decoder Programmer

This programmer is an item of PAL control equipment that can be used for test and training purposes in conjunction with ground and aircraft decoder controllers.

The T1549A will perform two functions when connected to a controller. The first function is to perform a duration and amplitude check of the aircraft and ground controller output data and power circuits for Category D systems. The second is to function as a coded switch simulator so that training in decoding operations can be performed with the T1549A and the aircraft and ground decoders. The T1549A will furnish feedback to the decoder that will allow the operator to determine whether an acceptable or unacceptable response has occurred. For training operations, seven different fixed codes are provided. Any of these codes will furnish OFF and/or LOCK and UNLOCK indications as appropriate.

The CT1504 Cable, described below, connects the T1535 Portable Decoder to the T1549A Decoder Programmer. This cable, currently used with all Air Force ground controllers, is shielded to afford EMR integrity in the range of 2 to 200 MHz. No external or auxiliary power cables will be required since the T1549A will be powered via the ground recoder power (which uses the power cable) or aircraft safe power.

T1555 Code Verifier

The T1555 (Figure 52) is a code verifier that is intended as a replacement for the T1539. Recode operation can also be performed.

T1558 Adapter

The T1558 adapter attaches to the T1555 Code Verifier to convert it to a recoding device.

T1563 Advanced PAL Controller and T1572 Portable Data Module

The T1563 Controller can function as a recoder/decoder for locking and unlocking the B61-6,8 PAL. It is also capable of recoding the PAL in the appropriate software mode. It uses the same cables, adapters, and power supplies as the T1535 Decoder and the T1536 Recoder [redacted] Unlike the T1535 decoder, the T1563 is not capable of unlocking multiple weapons in

DOE b(3)

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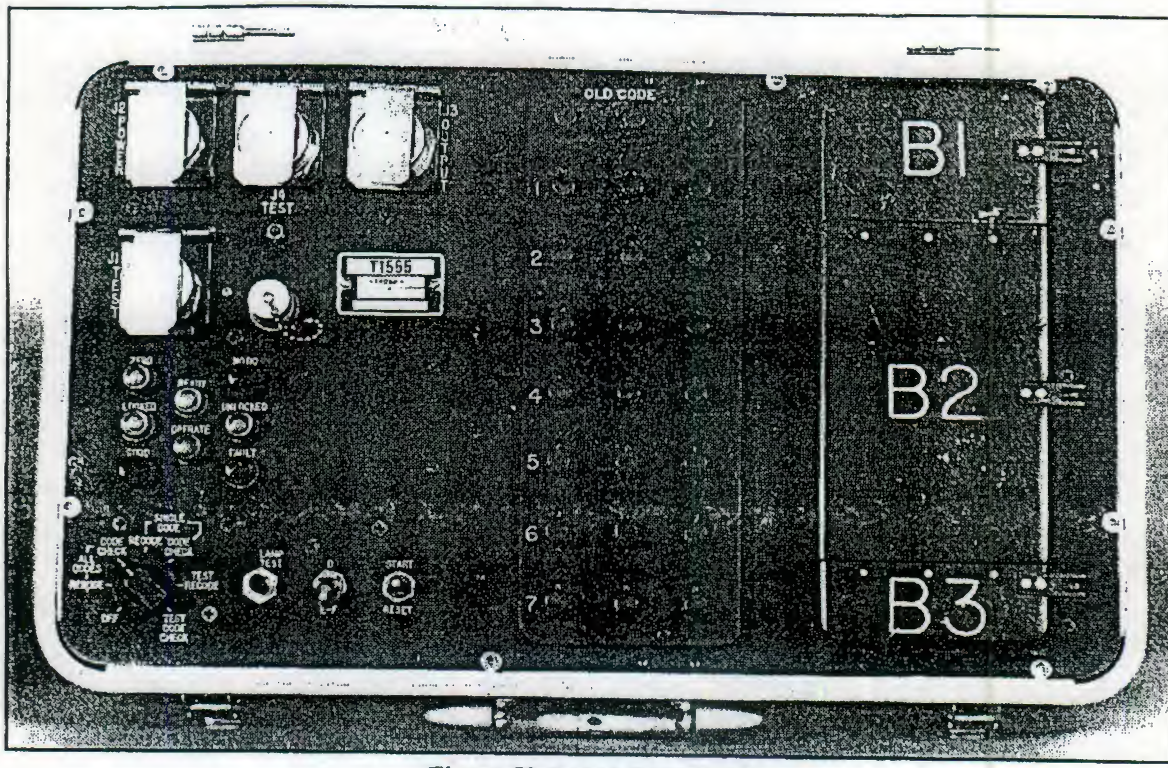
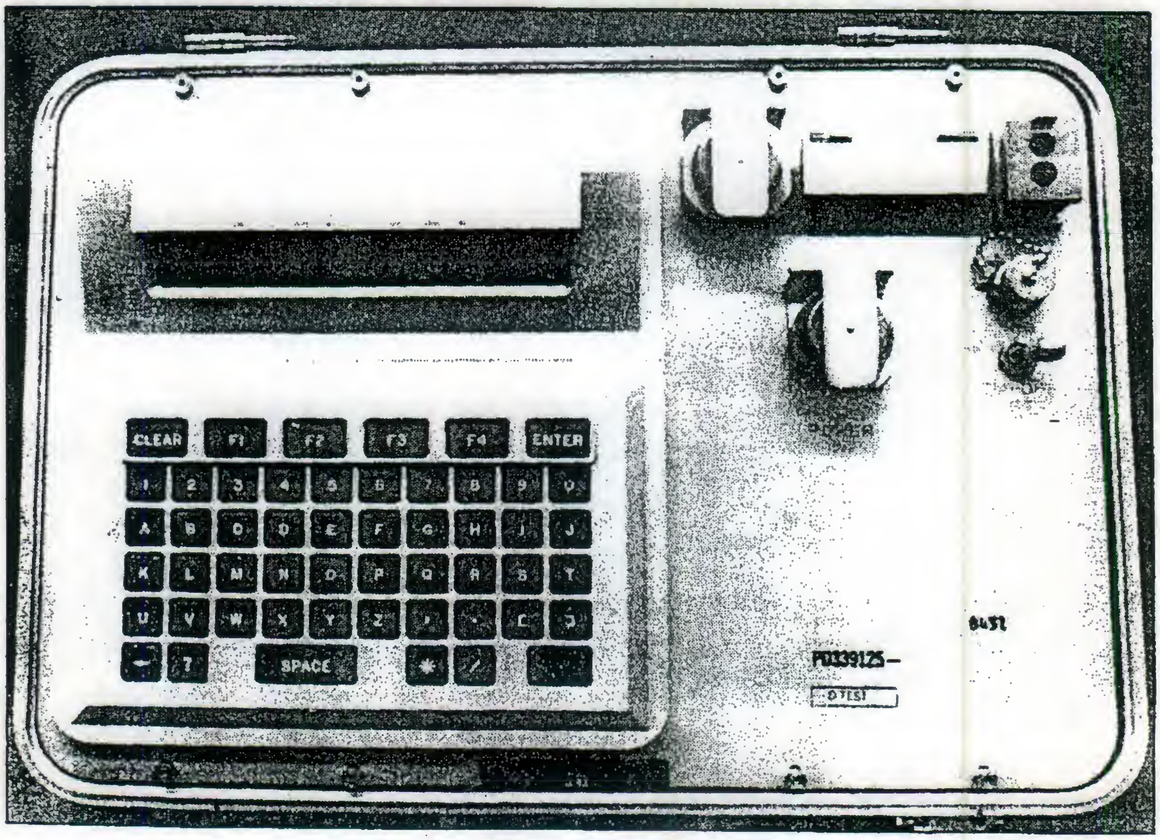


Figure 52. T1555 Code Verifier

Figure 53. T1563 Advanced PAL Controller



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parallel. Similarly, it can only recode one weapon at a time in the recoder mode (Figure 53).

The T1563 was developed to ease the burden of the PAL code management. It offers the user a more effective and efficient means to accomplish secure code selection, insertion, and verification with functions such as no-knowledge recode and automatic verify. It is compatible with all presently fielded PAL weapons, Air Force and Army, and the software can be changed to support future PAL interfaces. It also has a communications port to allow the transfer of information to and from the T1565 Headquarters Code Processor (HCP) using the T1572 Portable Data Module (PDM). It can be powered by a T436 battery or T1571A power supply. For ease of use, the T1563 is operator interactive and portable.

The T1572 Portable Data Module contains encrypted Permissive Action Link (PAL) recode and verification data generated either by the T1563 Automated PAL Controller or the T1565 PAL Headquarters Equipment. The T1572 is used as a mass storage device (nonvolatile read/write memory) to carry both recode and recode verification data (data is encrypted) between the T1563 and the T1565; also, the T1572 would be used by the T1565 to read Source Data PROMs (read only memories) generated by NSA containing encrypted recode data. The T1572 can also be used to interrogate the T1563 concerning previous weapon access.

T1569 Adapter

This adapter is used with the CT1504 Cable to connect the T1535, T1536, T1539, T1555, or T1563 PAL Controllers to the B61-6,8 Pullout Connector.

T1571 and T1571A Power Converters

The T1571 Power Converter can replace the T436 and the T436B power supplies whenever standard ac power is available. The T1571A is compatible with European ac voltage and frequency.

CT1478 Power Cable

This cable connects either a T1535, T1536, T1539, or T1563 with the T436B Power Supply.

CT1504 Controller Cable

This cable is used with the T1569 Adapter to connect either a T1535, T1536, T1539, T1555, or T1563 PAL Controller to the pullout connector.

CT1505 Test Cable

This cable is used with the T1569 Adapter to connect the T304C Continuity Test Set to the pullout connector to monitor the PAL. It will also mate directly with the J1 PAL connector on the MC4136 Preflight Controller.

7. Type Units and Joint Test Assemblies

General

Type weapons are non-war reserve, nonnuclear configurations that are designed and produced exclusively for testing, training, and evaluation by the DOE and DoD. DoD-type weapon requirements are determined by Field Command/Defense Nuclear Agency and the using military service via configuration meetings with the DOE design and production agencies. DoD and DOE concurrence on the design is obtained at these meetings. The B61-6,8 Joint Test Assembly (JTA) is a DOE-developed and produced configuration based on DOE/DoD requirements for use in the joint flight test program. JTA configurations are comprised of nonnuclear DOE war reserve weapon (WR) components and non-WR instrumentation that replaces part of the weapon system. The physical appearance and characteristics of JTAs approximate the WR configuration to the extent practicable.

B61-6,8 Type Units

Type 3 Loading, Handling, and Limited Maintenance Trainer

The Type 3 Trainer allows realistic training for all authorized DoD operational maintenance except limit life component exchange (LLCE) procedures. The Type 3, shown in Figure 54, has the following characteristics:

a. External dimensions, appearance, weight, and center of gravity are the same as WR to the extent that trainer handling procedures do not differ from WR handling procedures.

b. The Type 3 Trainer is unclassified and contains no hazardous materials.

c. The Center Bomb Subassembly contains ballast.

d. A switchable PAL monitor interface presents a "locked" or "unlocked" PAL monitor indication at both the pullout and preflight panel connectors. The unlocked PAL monitor occurs when the TA "Tens" switch is set to 10 on the MC4136 Preflight Controller. All other positions of this switch provide a locked PAL monitor. Decode/recode capabilities are not provided.

e. A fixed arm/safe monitor interface presents a "safe" status indication at the pullout connector. Arming and safing capabilities are not provided.

DOE b(3)

The Type 3 is marked as follows:

1. Permanent marking stating INERT TYPE 3 with serial number at the forward end of the center case in accordance with existing procedures.

2. Stenciled marking stating B61-6 TYPE 3 with design agency part number, alteration number, and serial number located immediately above the permanent marking.

B61-6 Type Trainers are generated from existing B61-0 Type 3A Trainers, using retrofit kits shipped to the field for the conversion of existing trainers.

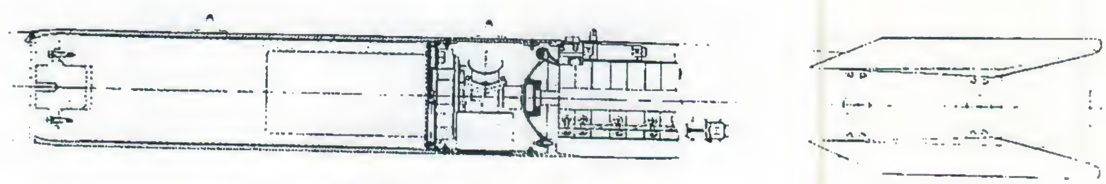

Figure 54. B61-6,8 Type 3 Trainer

DoD b(3)

Figure 55. B61-6,8 Type 3A Trainer

Type 3A Operation and Maintenance Trainer

The Type 3A Trainer allows realistic training for all authorized DoD operational maintenance including LLCE procedures. The Type 3A, shown in Figure 55, has the following characteristics:

a. External dimensions, appearance, weight, and center of gravity are the same as WR to the extent that trainer handling procedures do not differ from WR handling procedures.

b. The Type 3A Trainer is classified SRD, and contains no hazardous materials.

c. The center bomb subassembly contains a dummy secondary, a dummy primary, and all component decks with training components, cables, supports, pads and hardware.

d. A switchable PAL monitor interface presents a "locked" or "unlocked" PAL monitor indication at both the pullout and preflight panel connectors. The unlocked PAL monitor occurs when the TA "Tens" switch is set to 10 on the MC4136 Preflight Controller. All other positions of this switch provide a locked PAL monitor. Decode/recode capabilities are not provided.

e. A fixed arm/safe monitor interface presents a "safe" status indication at the pullout connector. Arming and safing capabilities are not provided.

f. An MC4136 Preflight Controller (Trainer) having a command disable coded device simulator with resettable T-handle is provided for command disable training. All other controls on the preflight controller panel exhibit WR-like manipulating capabilities.

The Type 3A is marked as follows:

1. Permanent marking stating INERT TYPE 3A with serial number at the forward end of the center case in accordance with existing procedures.

2. Stenciled marking stating B61-6 TYPE 3A with design agency part number, alteration number, and serial number located immediately above the permanent marking. B61-6 Type 3A Trainers are generated from existing B61-0 Type 3A Trainers, using retrofit kits shipped to the field for conversion of existing trainers.

Type 3E Loading and Handling Trainer

The Type 3E Trainer can be used for all loading and handling training in accordance with established DoD procedures. Figure 56 illustrates the Type 3E configuration, which has the following characteristics:

a. External dimensions, appearance, weight, and center of gravity are the same as WR to the extent that trainer handling procedures do not differ from WR handling procedures.

b. The Type 3E Trainer is unclassified, and contains no hazardous materials.

c. The parachute, spin rocket, gas generator, and all center case components are replaced by ballast.

d. A switchable PAL monitor interface presents a "locked" or "unlocked" PAL monitor indication at both the pullout and preflight panel connectors. The unlocked PAL monitor occurs when the TA "Tens" switch is set to 10 on the MC4136 Preflight Controller. All other positions of this switch provide a locked PAL monitor. Decode/recode capabilities are not provided.

e. A fixed arm/safe monitor interface presents a "safe" status indication at the pullout connector. Arming and safing capabilities are not provided.

f. An MC4136 Preflight Controller (Trainer) having a command disable coded device simulator with resettable T-handle is provided for command disable training. All other controls on the preflight controller panel exhibit WR-like manipulating capabilities.

The Type 3E is marked as follows:

1. Permanent marking stating INERT TYPE 3E with serial number at the forward end of the center case in accordance with existing procedures.

2. Stenciled marking stating B61-6 TYPE 3E with design agency part numbers, alteration number, and serial number located immediately above the permanent marking.

B61-6 Type 3E Trainers are generated from existing B61-0 Type 3E Trainers, using retrofit kits shipped to the field for conversion of existing trainers.

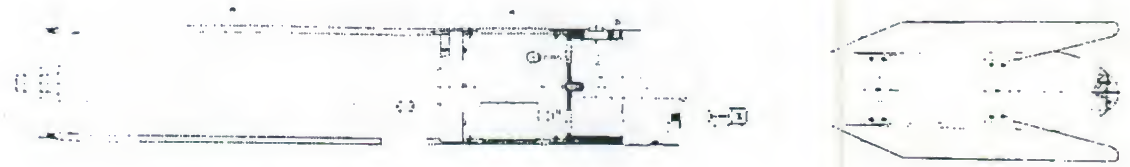

Figure 56. B61-6,8 Type 3E Trainer

B61-6,8 EOD Trainer

Explosive Ordnance Disposal (EOD) training will be provided with slide and viewgraph presentation material along with non-hazardous representative components. The presentation material shows all the classified, explosive, and hazardous material locations and identifying features of these components.

Type 5A DOE Training and Evaluation Unit

The B61-6,8 Type 5A is a functional, nonnuclear DOE trainer provided for pilot production tool-made sample (TMS) evaluation, quality assurance training, and production engineering evaluation. The functional components are of WR quality. The mock high explosive (IHE) and the simulated nuclear components are accurate representations of a WR system. The Type 5A will contain live explosive components (detonator, actuators, etc.).

Type 5B DOE Training and NMLT Test Evaluation Trainer

The B61-6,8 Type 5B is a nonnuclear, nonexplosive unit with functional WR components and electrical system. One of the two Type 5B units scheduled is a training/evaluation unit jointly used by the SNL Military Liaison and Quality Assurance Departments. The second Type 5B unit is used by the DOE for pilot production and quality assurance evaluations at the DOE production plant. The WR components are also used to evaluate the System Test Equipment (STE) associated with the NMLT and SLT programs.

The Type 5B is WR with the following exceptions:

a. The primary and secondary are nonnuclear, nonexplosive mockup assemblies with bridgewires representing detonators and actuators.

(b)(3) DOD

[redacted]

c. The gas generator, spin rocket, and MC4030 Driver are nonexplosive, bridgewire devices.

d. The parachute is a mass mockup trainer.

Type 5C DOE Training and Evaluation Unit

The B61-6,8 Type 5C is a functional, nonnuclear DOE trainer which only differs from a Type 5B by the dummy nose rather than a functional radar nose. An early type 5C is planned which will allow the production plant to design production fixturing, writing assembly and inspection procedures, and allow early training.

Type 5D DOE JTA Training Unit

The B61-6,8 Type 5D is a nonnuclear DOE JTA trainer with functional JTA components (MC4130, Energy Transfer Unit (ETU), Monitors, and CF cables). The Type 5D is configured for the JTA 1 (freefall air) configuration with a kit that will enable it to be reconfigured to the JTA 2 (laydown). This trainer provides the production plant opportunity to finalize tooling, gauging, testers, and assembly and inspection standards prior to the assembly of the first NMFT.

Joint Test Assemblies (JTA)

Seven JTA versions are defined for the B61-6,8 NMFT and SFT programs, as follows:

JTA1 — This configuration is used for tests of the freefall air (FFA) delivery option and does not contain IHE.

JTA2 — This configuration is used for tests of the retarded ground (laydown) delivery option and contains live IHE, mock Canned Subassembly (CSA), and a dummy radar nose.

JTA3 — This configuration is used for tests of the retarded air (REA) delivery option.

JTA4 — This configuration is used for tests of the retarded ground (laydown) delivery option and does not contain IHE but does contain a WR CSA and Acorn assembly. A dummy nose is provided.

JTA6 — This configuration is used for tests of the retarded ground (laydown) delivery option and contains mock IHE, mock CSA, and WR detonators whose performance is measured.

JTA7 — This configuration is used for tests of the

Table 3
B61-6,8 JTA Configuration Definition

	JTA1 FFA	JTA2 REG	JTA3 REA	JTA4 REG	JTA6 REG	JTA7 REG	JTA8 REA
Weapon Components							
Radar Nose	WR	MU	WR	MU	MU	MU	WR
Nuclear Secondary	MU	MU	MU	WR	MU	MU	MU
[redacted]	MU	WR	MU	MU	MU	MU	MU
	WR	WR*	WR	WR	WR	WR	WR
JTA Components							
Detonator Monitor	JT	—	JT	JT	JT	JT	JT
Load Assembly (Sugar Loaded Detonators)	—	JT	—	—	—	—	—

*Main detonators not fired on JTA2; special sugar loaded detonator assembly connected to firing set.

WR = War Reserve
MU = Mockup with WR electrical loading, as applicable
JT = Special JTA version

[redacted]

JTA8 — This configuration is used to test the contact fuze capability in the radar nose. The JTA8 is delivered in the retarded air delivery option with backup fuzing selected. The JTA8 is similar to a JTA3 except the radar portion of the nose is allowed to function at its selected altitude but is prevented from firing the JTA. The unit will fire by the contact fuzes in the radar nose or, if the impact does not give adequate voltage output from the contact crystal, by the backup timer output from the MC4138 Programmer.

For each version, maximum use is made of nonnuclear WR components with special attention paid to minimizing perturbation of the WR system. The JTA instrumentation is common to all versions. The configuration differences between the seven versions are shown in the table above.

B61-6,8 JTA Instrumentation

The B61-6,8 JTA Instrumentation may be categorized into passive recording of end event functions, of aircraft interface functions, and of other diagnostic functions. Nonvolatile memory in the flight recorder is interrogated as a post-test activity, and provides 62 data channels of information. End event monitored data includes detonator function, detonator timing, neutron levels, and neutron pulse timing. A means of monitoring gas transfer is part of the JTA instrumentation, but present planning does not now include gas transfer as a JTA event. [redacted]

8. Ancillary Equipment

Most B61-6,8 ancillary equipment (training, test, and handling equipment) is used on previous Mods of the B61. Any new or modified pieces of ancillary equipment necessary for B61-6,8 operations will be determined by a Joint Task Group (JTG) to be scheduled.

Shipping and Storage

H1125/H1242/H1012

The H1125 Bomb Cradle, either singly or stacked a maximum of two high with the H1242 Swivel Caster Set, or its alternate, the H1012 Hand Truck, is used for transportation and storage of the B61-6,8. These are carryover items that are interchangeable between the various B61 Mods.

H1127 Storage Bag

The H1127 is used on each B61-6,8 to store one-for-one items shipped with the weapon.

Field Test and Handling Equipment

Field test and handling equipment is authorized as required for B61-6,8 safety operations, bomb subassembly and assembly, monitoring, PAL control and training, limited-life component exchange (LLCE) and maintenance. Equipment previously developed for existing B61 Mods will be used wherever possible; new equipment will be designed only where necessary.

Safety Operations

The following carryover equipment will be authorized for use with the B61-6,8.

T290A Sampler, Air

The T290A is used to detect tritium in the air and measure the level of concentration. The T290A is an alternate for the T446 Tritium Alarm Monitor when used as a portable monitor.

T446 Alarm Monitor, Tritium

The T446 is used to detect tritium in the air and measure the level of concentration. It may be powered by the T2071 Power Supply. The T446 is an alternate for the T290A Air Sampler.

T464 Charger, Battery

The T464 can be used to operate the T446 Tritium Alarm Monitor from 115-V ac power while charging, or maintaining a charge on, the batteries in the T446. It will operate the T446 only with batteries installed. The T2071 Power Supply must be used with the T446 when batteries are not installed.

T2071 Power Supply

The T2071 allows direct and continuous use of the T446 Tritium Alarm Monitor from 115-V ac power lines.

Limited Life Component Exchange Equipment

The following carryover DOE-designed equipment is required to perform the planned LLCE, including weapon leak testing. New, additional equipment will be defined only if necessary.

H631 Handling Tool, Caster.

The H631 is used to facilitate turning casters on the H1012 Hand Truck or H1242 Swivel Caster Set. It is an alternate for the H1216.

H869 Strap, Hoisting

The H869 adapts the rear bomb subassembly to overhead handling equipment. It is used during parachute replacement or if the subassembly is removed for further access into the preflight and center bomb subassemblies.

H1004 Adapter, Hoisting, Bomb

The H1004 adapts the bomb to an overhead hoist or fork lift using bomb lugs as points of attachment. It is used to transfer the bomb from the H1125 Bomb Cradle to other equipment.

H1011 Socket Set, Socket Wrench

The H1011 is used to loosen and tighten electrical connector retaining nuts.

H1082 Pump and Control Box, Hydraulic

The H1082 is used with the H1134 Hydraulic Ram and the H1135 Ram Restraining Frame to apply pressure to the cover plate during removal and installation of the threaded ring in the center bomb subassembly.

H1130 Handling Device, Bomb Tail

The H1130 attaches to the tail bomb subassembly to provide for manual lifting. It is used during parachute replacement and removal to gain further access to the interior of the weapon.

H1134 Ram, Hydraulic

The H1134 is used with the H1082 Hydraulic Pump and Control Box and the H1135 Ram Restraining Frame to apply pressure to the cover plate for disassembly and reassembly of the center bomb subassembly.

H1135 Frame, Restraining, Ram

The H1135 is used with the H1134 Hydraulic Ram and H1082 Hydraulic Pump and Control Box to apply pressure to the cover plate during removal and installation of the threaded ring securing the cover plate.

H1136 Handling Device

The H1136 attaches to the cover plate of the center bomb subassembly and provides a means for manual removal and installation.

H1176 Wrench, Spanner

The H1176 is used to remove and install the threaded ring which secures the cover plate in the center bomb subassembly.

H1199 Wrench, Torque

The H1199 is used to remove and install nuts securing connectors of flat electrical cables to the ECA.

H1200 Wrench, Open End

The H1200 may be required to hold the hex studs while the nuts are being removed from the flat electrical connectors with the H1199 Torque Wrench.

H1201 Removal Tool, Electrical

The H1201 is used to disconnect the flat electrical connectors from the ECA.

H1216 Tool, Caster

The H1216 is used to facilitate turning casters of the H1012 Hand Truck or H1242 Swivel Caster Set. It is an alternate for the H631 Caster Tool.

H1228C Protector Kit, Electrical Connector

The H1228C contains the connector covers and shorting plugs required when any electrical disconnection is made during maintenance operations.

H1229 Stand, Bomb

The H1229 is used to rotate and secure the center bomb subassembly in a vertical position while components are being replaced. This stand is for use on board naval aircraft carriers. It is used with the H1238 Assembly Platform at other locations.

H1234 Wrench, Torque

The H1234 is used to tighten or install the studs in the MC4139 Junction Box located in the ECA.

H1238 Platform, Assembly Stand

The H1238 is used with the H1229 Bomb Stand during the replacement of limited life components. It is required at all locations except naval ships, and provides a base for the H1229.

H1248 Removal Tool, Machine Screw

The H1248 is required to loosen screws securing case sections together if commercial tools fail to loosen screws. It is an alternate for the H1354 Screw Removal Tool.

H1354 Screw Removal Tool

The H1354 is required to loosen the screws securing case sections together if commercial tools fail to loosen the screws. It is an alternate for H1248 Machine Screw Removal Tool.

H1379A Tool, Handling

The H1379A will be used for removal and installation of the ECA.

H1493 Wrench

The H1493 will be used to torque the gland into the Acorn and 2M assemblies.

T304C Test Set, Continuity, Multiple Purpose

The T304C is used to check electrical continuity. When connected to the umbilical connector of the B61-6,8, through the CT1520 cable, the T304C will verify the status of the MC2969 Intent Stronglink Switch. When used with the CT1505 cable through the J1 connector on the MC4136 Preflight Controller, the T304C will indicate the PAL status (lock/unlock).

T461 Panel, Leak Detection

The T461 is used with the T489 or T460 Leak Detection Chambers to check the seal integrity of the center bomb subassembly case.

T489 Chamber, Leak Detection

The T489 is used with the T461 Leak Detection Panel to check the seal integrity of the center bomb subassembly after replacement of limited life components in the B61-6,8.

Operational Capability

In addition to the limited life component exchange equipment listed above, the following carryover equipment will be authorized for use with the B61-6,8, as necessary, for maintenance including replacement of parachutes.

H563 Sling, Beam Type

The H563 attaches to the frame of the H1125 Bomb Cradle for hoisting with overhead handling equipment.

H587 Sling, Atomic Weapon Trailer

The H587 may be used as an alternate to the H563 Beam Type Sling for overhead handling of the bomb in the H1125 Bomb Cradle. Two shackles, P/N 870731-00, are required when using the H587.

H1012 Truck, Hand

The H1012 is an alternate for the H1242 Swivel Caster Set.

H1170 Socket, Socket Wrench

The H1170 is used to remove and install the gas generator during replacement of components in the tail bomb subassembly.

H1172 Installing-Removal Tool, Parachute

The H1172 is used to lift and guide the aft end of the parachute to its proper position during installation.

H1173 Handling Tool

Two H1173s are inserted through holes in the aft end of the tail bomb subassembly and into a plate on the parachute to aid in pulling and locating the parachute during its installation.

H1195 Pliers

When necessary to install or remove shorting plugs on MC1605 Series Battery Cable Assemblies in a T436B Power Supply, the H1195 may be used to disconnect or connect the cable assemblies at the junction box without removing the batteries from the case.

H1237 Socket, Socket Wrench

The H1237 is used during maintenance of MC1605 Series Batteries to remove and install terminal nuts to permit cable assembly replacement. It is also used to apply the proper torque to these nuts and to the nuts securing the battery terminal links.

H1242 Caster Set, Swivel

The H1242 attaches to the H1125 Bomb Cradle to provide mobility for the weapon. It is part of the shipping and storage configuration for the WR weapon and is included as special equipment if desired for training weapons.

H1247 Spacer, Case Section

Two or three H1247s may be used to ensure personnel safety during removal and installation of the tail bomb subassembly.

H1348 Wrench

The H1348 is used to connect or disconnect the pullout cable to the B61-6,8.

T431 Charger-Monitor, Battery

The T431 is used to monitor the electrical condition of and to charge the T436 or T436B Power Supply or the MC1605 Battery. It is an alternate for the T431A.

T431A Charger-Monitor, Battery

The T431A is used to monitor the electrical condition of and to charge the T436 or T436B Power Supply or the MC1605 Battery. It is an alternate for the T431.

T436 Power Supply

The T436 is used as a power supply for the T1535 Portable Decoder, T1536 Portable Recoder, T1539 Portable Code Verifier, and T1555 Portable Recoder/Verifier. The T436 is an alternate for the T436B described below for all but the T1563.

T436B Power Supply

The T436B is used as a power supply for the T1535 Portable Decoder, T1536 Portable Recoder, T1539 Portable Code Verifier, T1555 Portable Recoder/Verifier, and T1563 Automated PAL Controller. The T436B is an alternate for the T436.

T1528 Adapter, Test

DOE b(3)

T1535 Decoder, Portable

The T1535 is used with the T436 or T436B Power Supply to lock or unlock the B61-6,8. A CT1478 connects the T1535 to the T436B and a CT1495 adapts the CT1478 to the T436. The CT1504 connects the T1535 to the B61-6,8.

T1536 Recoder, Portable

The T1536 is used with the T436 or T436B Power Supply to recode or code check the B61-6,8. A CT1478 connects the T1536 to the T436B and a CT1495 adapts the CT1478 to the T436. The CT1504 connects the T1536 to the B61-6,8.

T1539 Code Verifier

The T1539 can be used with the T436 or T436B Power Supply to code check the B61-6,8. A CT1478 connects the T1539 to the T436B and a CT1495 adapts the CT1478 to the T436. The CT1504 connects the T1539 to the B61-6,8. Alternate for T1555 Portable Recoder/Verifier.

T1542 Adapter, Administrative

T1549A Decoder Programmer

The T1549A is used to perform a functional test of the T1535 and can be used as a simulated coded switch to permit training in use of the T1535.

T1555 Recoder/Verifier, Portable

The T1555 is used with the T436 or T436B Power Supply to code check the B61-6,8. A CT1478 connects the T1555 to the T436B and a CT1495 adapts the CT1478 to the T436. The CT1504 connects the T1555 to the B61-6,8. When used with the T1558 Recode Enable Adapter, the T1555 can recode the B61-6,8.

T1557 Adapter, Test

The T1557 is installed on the electrical connector of the T436B Power Supply cover to maintain a discharged power supply in the discharged state.

T1558 Adapter, Recode Enable

The T1558 can be used with the T1555 Portable Recoder/Verifier to permit recoding of the B61-6,8.

T1563 Controller, Automated, PAL

The T1563 can be used to recode, lock, unlock, code check, and verify codes in the B61-6,8.

T1564 Trainer, PAL

The T1564 may be used for training in performing six-digit PAL operations. It simulates the coded switch in the bomb.

T1568 Trainer, PAL

The T1568 may be used for training in performing six- and twelve-digit PAL operations. It simulates the coded switch in the bomb.

T1571 Electronic AC/DC Power Converter

The T1571 is used to convert 110-V ac 60 Hz to 28-V dc. It is an alternate to the T436/T436B for powering the T1535, T1536, T1539, T1555, and T1563.

T1571A Electronic AC/DC Power Converter

The T1571A is used to convert 115-230-V ac 50/60 Hz to 28-V dc and 115-230-V ac 400 Hz to 28-V dc. It is an alternate to the T436/T436B for powering the T1535, T1536, T1539, T1555, and T1563. The T1571A is an alternate for the T1571.

T1572 Portable Data Module

The T1572 is used to carry encrypted data to and from command headquarters and the recode detachments.

TYPE 3A Bomb Maintenance

The following equipment is required only to perform maintenance on B61-6,8 TYPE 3A Bombs.

H1249 Extractor

The H1249 is used to remove the energy absorber from the nose.

H1404 Fixture, Lift

The H1404 is used to permit removal of the support sleeve from Type 3A Bombs using overhead handling equipment.

9. Test and Evaluation

Nuclear System Tests

Nuclear Tests

[redacted]

DOE/DOD b(3)

Hydrodynamic Tests

[redacted]

DOE/DOD b(3)

B61-6,8 System Tests

Development Test Program

The B61-6,8 development test program will provide assurance that the system will function properly and safely throughout its stockpile life. Four categories of tests are being conducted to meet this objective: STS environment, laydown shock, flight, and special laboratory tests. Table 3 summarizes the B61-6,8 test program. The A, B, and C prefixes of the test unit numbers indicate the three phases of the program that relate the hardware development progress. Phase A employs first prototype hardware; new design major components are constructed by Sandia using commercially available piece-parts that have not yet been qualified. Phase B hardware will be constructed by the DOE manufacturing agency using mostly qualified piece-parts. If any design changes are identified by Phase A results, they will be incorporated. Phase C hardware is WR-quality material constructed during production qualification (TMS) activities at the DOE plant. About twenty functional AF&F test units will be assembled in addition to many nonfunctional, units designed to collect environmental data.

[redacted]

DOE b(3)

No tests will be conducted in the areas of acoustic, pressure, humidity, precipitation, wind, and suspended particle environments. Bomb ballistic performance will be monitored and evaluated to ascertain applicability of Navy aircraft weapon delivery software.

STS Environmental Series Tests

These tests will demonstrate the B61-6,8 will function reliably after experiencing the extremes of mechanical shock, vibration, and temperature tabulated or inferred (aircraft carriage and flight conditions) in the STS for Stages 1 to 5.

The SE (STS environments) test units will verify that the B61-6,8 will survive the environments. In addition, FT (flight test) units beginning with FT4 will be subjected to STS environments before being flown. The STS test series will verify weapon reliability after handling, storage, transportation, and flight environments based on worst-case data accumulated via prior B61 development programs.

Laydown Shock Tests

The ability of the B61-6,8 nuclear system and firing set to survive the severe mechanical shocks of laydown delivery against hard, irregular targets will be verified both in the special tests and flight tests. Drop tower tests were conducted durign the B61-7 program to measure the response of the nuclear system and AF&F to impacts with hard, irregular targets. The B61-7 test unit was dropped with its longitudinal axis horizontal to strike a railroad rail at the weapon primary and at the firing set station. Because the B61-6,8 is identical to the B61-7 at these stations, the conclusion from these tests, coupled with B61-3/4 testing and analysis, is that no release altitude restrictions are required in using the B61-6,8 against hard, irregular targets.

The rocket launcher facility will be used to simulate worst-case slapdown and longitudinal impact conditions with the unit at both its maximum and minimum temperatures. From the early tests, component response data at the Acorn assembly was obtained which will be used in component qualification. Additional worst-case laydown delivery conditions will be conducted with fully functional AF&F hardware at maximum and minimum temperatures at the rocket launcher facility.

Table 4. B61-6,8 Development Test Plan

TEST Ident	Facility	Configuration	Hardware Quality	Date	Purpose
LS1(A)	SNL	Short Center Case	MU	6-8/88	Acorn survivability in simumlated laydown
ES1(A)	SNL	AF&F, open setup	FF	6/88	Bench test of new breadboard components & new tester
SLIM(A)	SNL	Center Case	MU	9/88	First Sandia Los Alamos Interface Mockup
SE1(A)	SNL	Bomb, lateral	MU	12/88	Maximum laydown impact using rocket launcher, Acorn
SE2(A)	SNL	Bomb, axial	MU	4/89	Maximum laydown impact using rocket launcher, Acorn
SE3(A)	SNL	Bomb	FF	2,3/89	STS shock, vibration with fully functional AF&F
ND1(A)	LANL	Primary +	MU	6/89	Time of shock arrival at neutron generator location
SLIM2(A)	SNL	Center Case	MU	3/89	Second Sandia Los Alamos Interface Mockup
SLIM3(B)	SNL	Center Case	MU	6/89	Sandia Los Alamos Interface Mockup, "WR" foam
MAT1(B)	LANL	Center Case	FF	7/89	One-year Accelerated Aging Unit for material comp.
MAT2(B)	SNL	Preflight+Tail	FF	4/89	Resultant salt air environment inside tail & preflight
CTU1(B)	SNL	Special	FF	7/89	"Intent-enabled" TSSG aircraft compatibility test unit
ECT1(B)	SNL	AF&F+JTA	FF	7/89	Bench test followed by bomb configuration test of JTA
SE5(B)	SNL	Bomb-JTA	FF	8/89	STS test series followed by max. lateral impact with JTA
SE6(B)	SNL	Bomb-WR	FF	6/89	STS + max. lateral impact at min. temperature (WR)
SE7(B)	SNL	Bomb-WR	FF	7/89	STS + max. lateral impact at max. temperature (WR)
SE8(B)	SNL	Bomb	MU	6/89	STS + max. axial impact at min. temperature, Acorn surv.
SE9(B)	SNL	Bomb	MU	7/89	STS + max. axial impact at max. temperature, Acorn surv.
FT1(B)	WSMR	Bomb	FF	8/89	A-4, JTA-6
FT2(B)	WSMR	Bomb	FF	9/89	A-7E, WR, REG
FT3(B)	WSMR	Bomb	FF	9/89	A/F-18, JTA-8
FT4(B)	WSMR	Bomb	FF	11/89	A-6, JTA-3 preceeded by STS environments
FT7(B)	Dabob	Bomb	FF	1/90	F/A-18, JTA-7 preceeded by STS environments
FT6(B)	TTR	Bomb	FF	3/90	A-7E, WR, REG preceeded by STS environments
FT5(B)	TTR	Bomb	FF	5/90	B-1B, JTA-2 preceeded by STS environments
FT8(B)	TTR	Bomb	FF	7/90	F/A-18, REG, WR preceeded by STS environments
FT9(B)	TTR	Bomb	FF	9/90	B-52H CSRL, JTA-8, preceeded by STS environments
FT10(C)	TTR	Bomb	FF	11/90	F/A-18, JTA-1 preceeded by STS environments
FT11(C)	WSMR	Bomb	FF	2/91	F/A-18, JTA-6 preceeded by STS environments
FT12(C)	TTR	Bomb	FF	2/91	F/A-18, Design Demonstration Test preceeded by STS
ND2(B)	SNL	Center Case	FF	6/90	Neutron Generator "proof test"
SE10(B)	SNL	Center Case	MU	5/89	Hydrostatic pressure capability of center case
NS1(B)	SNL	Bomb	FF	12/89	Nuclear safety certification unit (combined env.)
NS2(B)	SNL	Bomb	FF	3/90	Electro-static Discharge (reliability) + nuc. cert. unit
UC1(B)	SNL	Bomb	FF	7/90	Command disable effectiveness
UC2(B)	SNL	Special	FF	4/90	Command disable bench tests (multiple), MU loads
EM1(B)	SNL	Bomb	FF	2/90	EMR evaluation
SE11(B)	SNL	Bomb	FF	6/90	STS + max. lateral impact, late development components
SE12(B)	SNL	Bomb	MU	7/90	[redacted] DoD b(3)
TR1(B)	SNL	Bomb	FF	3/90	ET-5C trainer for Pantex (WR)
TR2(B)	SNL	Bomb	FF	6/90	ET-5D trainer for Pantex (JTA)
TR3(B)	SNL	Bomb	FF	6/90	Type 3, 3A, 3E Training unit evaluations

Test Ident Code:

- LS = Lab Simulated laydown shock
- ES = Electrical System
- SLIM = Sandia Los Alamos Interface Mockup
- SE = STS Environments (shock, vib., thermal)
- ND = Nuclear Development
- MAT = Material Compatibility
- CTU = Compatibility Test Unit
- ECT = Electrical Compatibility Test
- FT = Flight Test
- NS = Nuclear Safety
- UC = Use Control
- EM = Electromag. Rad.
- TR = Trainer evaluation

Flight Tests

The flight test program will consist of approximately 12 air drops. Eight are now planned to be low-altitude laydown deliveries. Because worst-case slapdown shocks are produced at minimum release velocities, the tests are concentrated in that area. Two flight tests will be retarded airburst and two freefall airburst. All data collection on these tests will utilize the JTA system in development. Some flight tests will be conducted without any instrumentation on-board to establish the WR/JTA equivalence.

Special Tests

In addition to the tests discussed above, special purpose tests will be performed to obtain information on particular elements of B61-6,8 design and performance. Component response to aircraft vibration was measured during the B61-3,4 and B61-7 development programs in the Vibration Flyaround (VFA) tests. It has been determined that the FB-111A produces the most severe in-flight vibration environment and these levels will be used in the STS environment preconditioning for the B61-6,8. Only if the new Navy A12 aircraft is available, will it be necessary to add B61-6,8 VFA tests. Similarly, mechanical shock produced by aircraft ejection from present Navy bomb racks has previously been determined.

Electromagnetic Radiation (EMR)

Tests to investigate the EMR environment as defined in the STS will be conducted. Previous test results on B61-3,4 and B61-7 were used as appropriate to establish areas of concern for the B61-6,8. No new areas of concern are now identified except the EMR specification has changed in the new STS and the response of the B61-6,8 will be determined.

Compatibility

Three Sandia/Los Alamos Interface Mockup (SLIM) units, representing succeeding stages of hardware development, will be used to confirm the mechanical compatibility of Sandia and Los Alamos components. The compatibility of materials used in the center bomb subassembly will be studied in an accelerated aging unit. Preliminary aircraft compatibility checks will be made prior to all flight tests, with particular emphasis on assuring the reliable performance of the new intent-enabled MC4137 TSSG. Tests will also be performed by Sandia and by Los Alamos to confirm adequate standoff distance and the proper functioning of the generators in the extreme electrical and mechanical environments at weapon detonation.

Detailed information on each of the tests conducted in the B61-6,8 development program will be available in Bomb Books on file at SNL and summary test reports.

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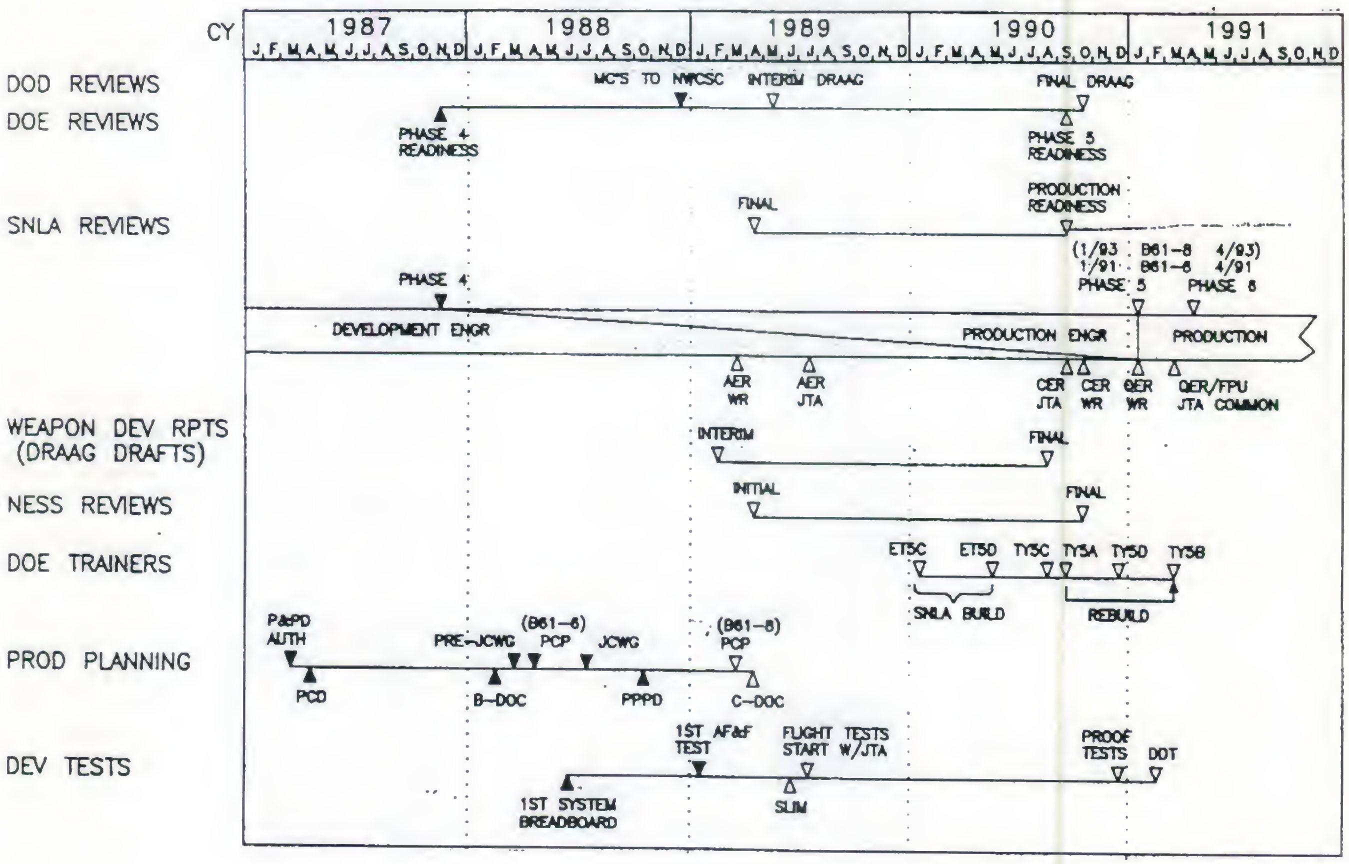
10. Programming

Since the B61-6,8 is a factory retrofit of the existing B61-0,2,5 stockpile, the normal early program support through Phase 1 and Phase 2 studies involving both nuclear laboratories are not appropriate. The chart below lists the significant development and production milestones to be accomplished.

B61-6/8 PROGRAM SCHEDULE

DOD-DOE/SNLA MAJOR MILESTONES



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APPENDIX A

Military Characteristics for the B61-6,8
(Proposed)

Military Characteristics | **Comments**

1. (U) *General*

1.1 (C-FRD) *Purpose*: This portion of the Military Characteristics (MC's) specifies the requirements of the Department of Defense (DOD) to the Department of Energy (DOE) for the B61 Mods 6 and 8 (B61-6,8) gravity bombs. The modifications are to incorporate modern safety, security, and operational features. The B61-6, 8 designs shall have the features delineated in paragraph 2 of these MCs.

1.1.1 (U) The B61 Mod 6 is a modification of the B6l Mod 0.

1.1..2 (U) The B61 Mod 8 is a modification of the B61 Mods 2 and 3.

1.2 (U) *Contingencies*: The design, development, test and evaluation of the bombs will be coordinated by the B61 Project Officers Group (POG) . Should it appear impractical to meet any of these characteristics or that meeting them will unduly delay development or production of the bombs, incur unreasonable costs, or require excessive special nuclear materials, prompt notification shall be made by the Lead Project Officer (LPO) via service channels to the Nuclear Weapons Council Standing Committee (NWCSC) .

1.3 (U) *Competing Characteristics*: In the event that compliance with these MCs results in design conflict, priorities shall be observed in the order listed below, giving consideration to tradeoffs which allow higher priority MCs to be attained while minimizing the degradation of the competing lower priority MCs. Operational effectiveness, technical feasibility, schedule, and cost will provide the basis for making tradeoffs among the desired competing characteristics. Tradeoffs may be made with the guidance and approval of the B61 POG. The NWCSC must approve all MC changes.

1.3.1 (U) Nuclear Safety
1.3.2 (U) Minimum Intrinsic Radiation
1.3.3 (U) Reliability
1.3.4 (U) Physical Characteristics
1.3.3 (U) Yield
1.3.6 (U) Radioactive Material Dispersal
1.3.7 (U) HE Safety
1.3.8 (U) Economical Use of Nuclear Material
1.3.9 (U) Operational Simplicity
1.3.10 (U) Command and Control Features
1.3.11 (U) Maintenance

2. (U) *Bomb Characteristics*

2.1 (U) *General Considerations:*

2.1.1 (U) The bombs shall not require functional testing in the stockpile.

2.1.2 (U) The bombs shall be designed so that the likelihood of plutonium dispersal in an accident environment is minimized.

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2.1.4 (U) Provision shall be made for easy removal of some component of the electrical system vital to the function of the bombs. This provision shall not compromise Service operational requirements or storage criteria. Since this feature is a use-control function only, the bomb must meet all nuclear safety requirements in paragraph 2.8 whether the separable component is installed or removed.

2.1.3 (U) The design of the bomb shall be consistent with the environmental conditions delineated in the stockpile-to-Target Sequence (STS) and shall be deliverable in accordance with aircraft profiles in the STS.

2.2 (U) *Operational Considerations:*

[redacted]

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2.3.3 (U) Groundburst (Freefall)

2.3.4 (U) Laydown: (Retarded delayed groundburst.) The firing times shall be the same as the parent bomb.

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2.3.6 (U) The bombs shall be capable of functioning properly in water depth to the limits of the Laydown timers.

2.4 (U) *Physical Characteristics:*

2.4.1 (U) Weight: 770 pounds (nominal)

2.4.2 (U) The length shall be 141.6 inches maximum.

2.4.3 (U) The body diameter shall be 13.3 inches maximum.

2.4.4 (U) The shape and geometry of the bombs shall be such as to minimize drag and adverse flight characteristics on the strike aircraft during all phases of the flight profile.

2.4.5 (U) War reserve bombs shall be identified with permanent and distinctive markings.

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2.5 (U) *Aircraft Compatibility*

2.5.1 (U) The bombs shall be capable of carriage (single and multiple) and release under operational conditions from the following carriers without aircraft modification:

AIRCRAFT	CARRIAGE
A-4M	Single External
A-6E,G	Multiple External
F/A-18A,C	Multiple External
A-7E	Multiple External
A-12	Multiple

2.5.2 (U) The bombs shall be compatible with aircraft both with and without a Unique Signal Generator (USG) capability.

2.6 (U) *Reliability Characteristics:*

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2.7 (U) *Environmental Characteristics:*

2.7.1 (U) The bombs shall retain full operational capability during and after exposure to the normal environmental conditions specified in the STS.

2.7.2 (U) After exposure to abnormal environments specified in the STS, the bombs are not expected to retain full operational reliability, but should still maintain the standards of safety set forth in these MCs.

2.8 (U) *Safety Characteristics:*

2.8.1 (U) The requirements outlined in this section should be considered minimal. They are not intended to restrict the designer in the advancement of nuclear safety.

2.8.2 (U) There shall be no irreversible functioning of any enabling or arming component prior to release of a bomb from an aircraft.

2.8.3 (U) In the event of a detonation initiated at any one point in the bomb primary high explosive, the probability of achieving a nuclear yield greater than the energy equivalent to that produced by detonation of four pounds of trinitrotoluene (TNT) shall not exceed one in one million (1×10^{-6}).

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2.8.5 (U) The probability (per bomb lifetime) of a premature nuclear detonation of a bomb for the normal environments described in the STS shall not exceed:

2.8.5.1 (U) Prior to prearm (which includes application of the arming power and the unique intent enabling stimulus) and prior to release from the aircraft and in the absence of the trajectory stimulus, 1×10^{-9}.

2.8.5.2 (U) After prearm and prior to release from the aircraft, and in the absence of trajectory stimulus, 1×10^{-6}.

2.8.5.3 (U) After prearm and after release from the aircraft, and in the absence of trajectory stimulus, 1×10^{-3}).

2.8.6 (U) The probability (per occurrence) of a premature nuclear detonation in the normal release envelope after receipt of the trajectory stimulus shall not exceed:

2.8.6.1 (U) Prior to expiration of the safe separation time, 1×10^{-3}.

2.8.6.2 (U) After expiration of the safe separation time and prior to the intended detonation, 1×10^{-2}.

2.8.7 (U) The probability (per occurrence) of a nuclear detonation of a bomb for individual or credible combinations of abnormal environments specified in the STS shall not exceed:

2.8.7.1 (U) In the absence of any unique intent and trajectory stimuli, 1×10^{-6}.

2.8.7.2 (U) After receipt of the unique intent and in the absence of the trajectory stimulus, 1×10^{-3}

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2.8.9 (U) For the B61-6, 8 it shall be possible to monitor the safe status of a bomb electrically in any STS configuration. It shall be possible to electrically safe the bomb at any point in the STS prior to release from the aircraft. Both of these requirements apply to normal environments only.

2.8.10 (U) The initiation of the bomb arming sequence shall require both AMAC power at the time of weapon release and bomb separation from the delivery aircraft.

2.8.11 (U) Monitor circuits in a bomb which are associated with the in-flight monitor and control functions shall be adaptable to in-flight monitor and control systems employing monitor power limited to a value less than that which would activate any bomb components considered critical from a safety standpoint.

2.8.12 (U) The bomb shall be designed to facilitate Render Safe Procedures (RSP) which return the weapon to a condition that is as safe as reasonably achievable. The bomb design, RSP, and EOD operations should allow the bomb to be shipped with a minimum of special storage and movement constraints.

2.8.13 (U) The design shall:

2.8.13.1 (U) Minimize radiological, chemical toxicity, or other hazards during maintenance, handling, and other opera-

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tions in normal environments. Radiological hazards should be as low as reasonably achievable when a bomb is subjected to abnormal environments.

2.8.13.2 (U) Use insensitive high explosives (IHE). [redacted]

2.8.15 (U) If any energy storage components are included within a bomb that are capable of prearming or arming the bomb (other than primary power sources), they shall discharge if energy input is interrupted. The time required for discharge to a safe level shall be the minimum time practicable after removal of arming power.

2.8.16 (U) Bomb arrays shall remain subcritical in all planned logistical and operational configurations and under single or credible combinations of abnormal environments as specified in the STS.

2.9 (U) *Command and Control Characteristics:*

2.9.1 (U) Permissive Action Link (PAL): The B61-6, 8 shall incorporate CAT D PAL in accordance with the general characteristics outlined in the OSD letter.[3]

2.9.2 (U) Command Disablement (CD) :

2.9.2.1 (U) Nonviolent Command Disablement systems for the B61-6, 8 shall be designed in accordance with the OSD letter[3]. A command disabled bomb shall be safely transportable through normal nuclear weapon supply channels.

2.9.2.2 (U) The disablement system designs and assessment of effectiveness shall be in accordance with the intent of the OSD policy letter.[3]

2.9.2.3 (U) The bomb system shall provide for manual insertion of a three-digit code on the bomb preflight panel in preparation for disablement. The preparation for disablement shall be reversible.

2.9.2.4 (U) Disablement shall be accomplished by an action which is separate and distinct from the action for preparation for disablement.

2.9.2.3 (U) Disablement shall not require PAL codes or PAL code equipment.

2.9.2.6 (U) The CD systems shall be capable of operation with the PAL in any mode or state.

2.9.2.7 (U) A capability to visually and tactilely determine the status (disabled or not disabled) shall be provided.

[redacted]

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2.9.2.9 (U) Under normal environmental conditions, the probability of accidental disablement due to the CD system in the absence of any input stimuli except for normal stimuli (e.g., Category D PAL recoding, decoding, and status checks) shall not exceed:

2.9.2.9.1 (U) 1×10^{-5} per bomb year (with 1×10^{-5} per weapon lifetime desired) prior to preparation for CD.

2.9.2.9.2 (U) 1×10^{-3} after preparation for CD but prior to the activate stimuli.

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2.10 (U) *Maintenance, Monitoring, Transportability, Storage, and Handling Equipment Characteristics:*

2.10.1 (U) Consistent with paragraphs 1.3, 2.1.3, and 2.6.2, Limited Life Component Exchanges (LLCE) and periodic maintenance shall be minimized. Provisions shall be made for simple replacement and ease of access with a minimum of downtime during LLCE.

2.10.2 (U) Maintenance procedures and DOE-supplied support equipment shall be functionally and physically compatible with existing maintenance procedures and equipment insofar as practicable.

2.10.3 (U) Preplanned, scheduled, or periodic maintenance (excluding PAL) shall be minimized in the stockpile.

2.10.4 (U) DOE-supplied support material and equipment to be used with these bombs shall be capable of withstanding the same STS environmental conditions required of the bombs in areas where they are to be used together.

2.10.5 (U) DOE-supplied shipping and storage material shall be compatible with military transportation systems and handling and storage procedures as described in the STS.

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[3](U) Office of the Secretary of Defense letter "General Characteristics for Permissive Action Link Systems Used with Nuclear Warheads" dated 18 April 1980.